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DOT-HS-805-596

LIGHT TRUCK AGGRESSIVITY STUDY-TASK 3 ANALYSIS REPORT

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FINAL REPORT

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16. Abstract

A series of seven full-scale truck-to-car and one car-to-car crash tests was conducted as required under NHTSA contract DOT-HS-8-01942, "Light Truck Aggressivity Study." This analysis report summarizes the work performed and presents analysis of the relative aggressivity of a light truck compared to a full-sized passenger car in frontal, side and rear collisions.

The analyses are based on comparisons of pertinent structural and occupant response parameters from the conducted tests with available data from previous NHTSA-sponsored collisions. Although the data base for the analysis was insufficient for an exact determination of light truck aggressivity, the results of this study appear to indicate that the light truck is slightly more aggressive than a full-size passenger car.

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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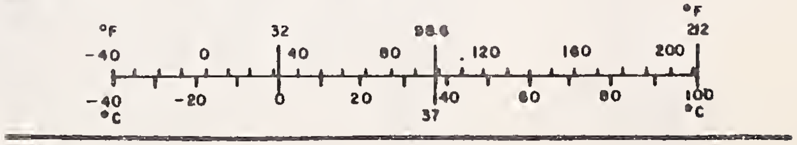
*1 in = 2,54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2,25, SD Catalog No. C13.10 286

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

1.1 BACKGROUND

In a safety conscious society, a highway vehicle should not be designed independently of other vehicles, using the same roadway systems. It must be compatible with the mix of vehicles to which it may be exposed in the highway environment. The design feature which addresses this aspect of a car's performance is its aggressivity: the characteristics of a vehicle which help reduce injuries to occupants of a struck vehicle during a collision.

An automobile may provide a high level of crash survivability for its own occupants in rigid barrier crashes, but can create an excessively hostile crash environment for other vehicles in car-to-car crashes (i.e., rendering a low probability of survival for the occupants of the other car). Such a vehicle may be called "aggressive."

Vehicle aggressiveness must ultimately be defined in terms of occupant survivability in the struck vehicle. This may be quantified in terms of providing efficient structural interactions between the two vehicles, maintaining integrity of the occupant compartment space, and in terms of the degree to which the struck vehicle's structure/restraint systems provide crash protection to the occupants.

A vehicle that is overly-aggressive poses two types of hazards to other vehicles in crashes. It may cause injury-producing penetration (intrusion) of the occupant compartment of the other vehicle in crashes that would otherwise not produce injury, and it can reduce the mutual (combined) structural collapse and stopping distance required for survival. These hazards result basically from three vehicle characteristics identified by Mr. M. Harmon and Mr. M. Ventre of the Peugot-Renault Association at the 2nd and 3rd

International ESV Conferences (References 1, 2, and 3) as structural aggressiveness, mass aggressiveness, and architectural agressiveness.

Structural aggressiveness is related to the vehicle's overall or local stiffness, or load/deflection characteristics. Mass aggressiveness pertains to adverse effects related to vehicle mass ratio or heavy component mass (such as engines and bumpers) effects on the crash dynamic interaction. Architectural aggressiveness pertains mainly to the adverse effects of stiff exterior vehicle profiles and protrusions.

To provide a better understanding of the nature of aggressivity for the light truck vehicle class, Dynamic Science conducted a research study for the National Highway Traffic Safety Administration to help define aggressivity of light trucks relative to passenger cars. The purpose of this program was to develop a data base in support of current and future Federal Motor Vehicle Safety Standards. The results of this research effort are presented in this report.

1.2 PROGRAM SUMMARY

The main objectives of this program were:

- To provide light truck-to-car collision data.
- To study the aggressivity of light trucks compared to the aggressiveness of passenger cars.
- To support current vehicle standards and provide information to upgrade future standards.

In order to accomplish this, the following four tasks were conducted:

- Task 1 - Prepare Plan of Work and Methodology. This plan illustrated that the contract efforts would be properly planned, implemented, controlled, completed on schedule and within contract costs (see Figure 1-1).

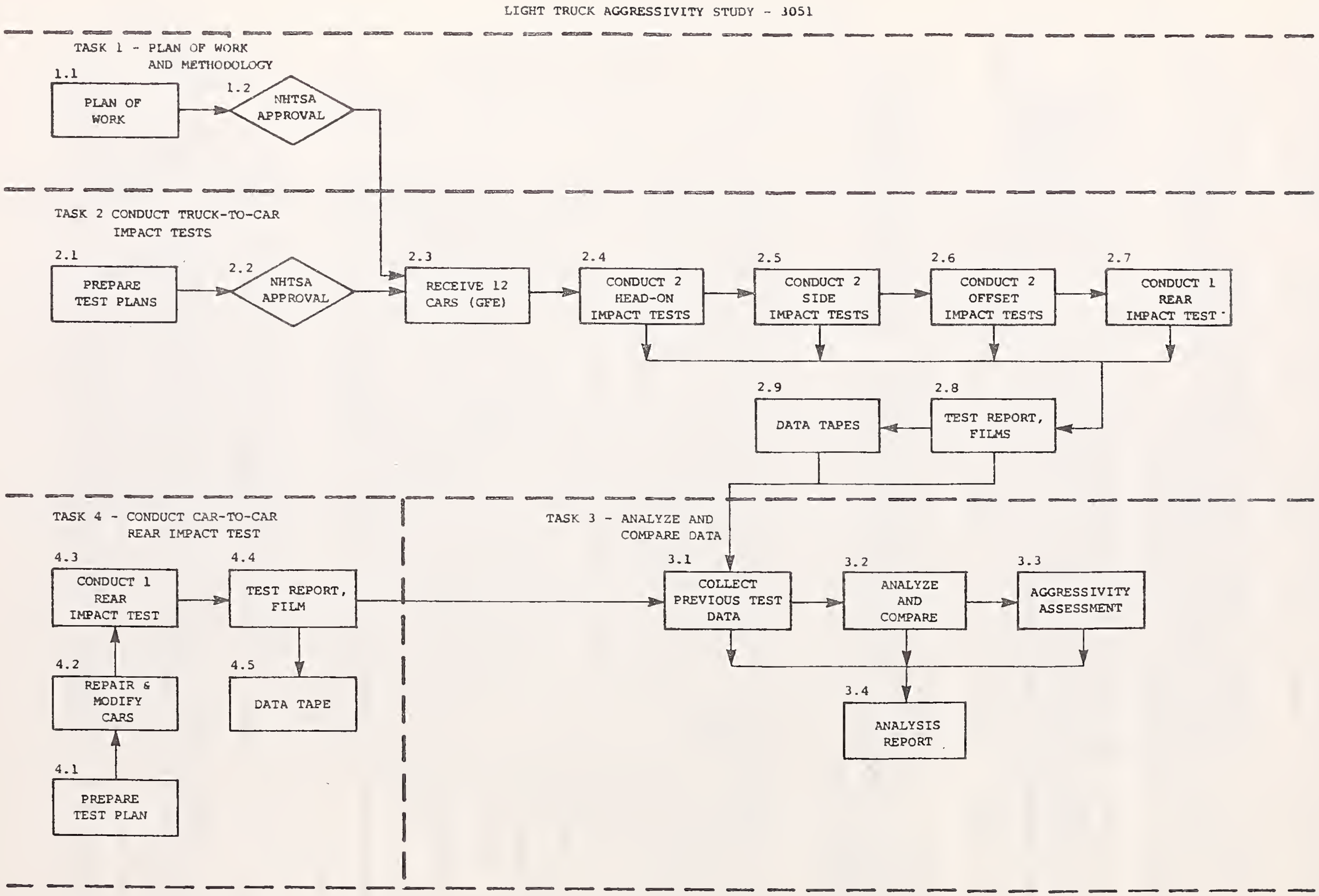
- Task 2 - Conduct Truck-to-Car Crash Tests. A series of seven truck-to-car crash tests were conducted in the head-on, right offset, left side, and rear impact crash modes (References 4 through 7).

- Task 3 - Analysis and Comparison of Test Data. Resulting test data were analyzed, evaluated, and compared with previous car-to-car crash tests. An assessment was made of the causes of pickup truck aggressiveness and how this aggressiveness differs from that of passenger cars. This report summarizes this effort.

- Task 4 - Conduct a Car-to-Car Symmetric Rear-End Impact Test. A car-to-car rear-end impact test was added to the program to supply data for this type of test (Reference 8).

The test matrix for this project is shown in Table 1-1 and consisted of eight tests. In the first six tests (Task 2), the bullet vehicle was a 1979 C-10 Chevrolet Pickup Truck while the target car was either a 1978 Plymouth Horizon or a 1979 Chevrolet Impala. The purpose of these tests was to develop a data base for assessing the aggressivity of the Chevrolet Pickup Truck. To evaluate its aggressivity, a comparison was needed between the performance of the Chevrolet Pickup Truck in these tests and the performance of a passenger vehicle under similar test conditions. The data for the passenger vehicles was selected from previous test reports (References 9 through 13) and a comparison of the test conditions is shown in Table 1-2.

In Table 1-1, Tests 7 and 8 (symmetric rear-end impacts) are directly comparable tests since the target vehicles are equivalent and the bullet vehicle in Test 7 is a Chevrolet Pickup Truck, while the bullet vehicle in Test 8 is a Chevrolet Caprice. These two tests are presented in Table 1-2 as the seventh entry for comparison.


LIGHT TRUCK AGGRESSIVITY STUDY - 3051
TASK 1 - PLAN OF WORK AND METHODOLOGY
1.1
PLAN OF WORK
1.2
NHTSA APPROVAL
TASK 2 CONDUCT TRUCK-TO-CAR IMPACT TESTS
2.1
PREPARE TEST PLANS
2.2
NHTSA APPROVAL
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3.1
COLLECT PREVIOUS TEST DATA
3.2
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3.3
AGGRESSIVITY ASSESSMENT
3.4
ANALYSIS REPORT

Figure 1-1. Program Flow Diagram.

TABLE 1-1. SUMMARY OF VEHICLE-TO-VEHICLE TEST CONDITIONS

Test No.	Test Date	Test Condition	Test Vehicle*	Test Weight (lb)	Closing Speed (mph)
3051-1	10/10/78	Head-on (Symmetric)	B - 1979 C-10 Chevrolet Pickup Truck	5180	61.54
			T - 1978 Plymouth Horizon	2688	
3051-2	10/12/78	Head-on (Symmetric)	B - 1979 C-10 Chevrolet Pickup Truck	5182	74.50
			T - 1979 Chevrolet Impala	4404	
3051-3	10/23/78	Left Side - 90° (℄ of A at H-pt.)	B - 1979 C-10 Chevrolet Pickup Truck	5189	29.74
			T - 1978 Plymouth Horizon	2686	
3051-4	11/17/78	Left Side - 90° (℄ of A at H-pt.)	B - 1979 C-10 Chevrolet Pickup Truck	5183	29.99
			T - 1979 Chevrolet Impala	4398	
3051-5	10/30/78	Right Offset (21 in.)	B - 1979 C-10 Chevrolet Pickup Truck	5183	61.62
			T - 1978 Plymouth Horizon	2682	
3051-6	11/28/78	Right Offset (21 in.)	B - 1979 C-10 Chevrolet Pickup Truck	5176	75.78
			T - 1979 Chevrolet Impala	4397	
3051-7	02/01/79	Rear-end (Symmetric)	B - 1979 C-10** Chevrolet Pickup Truck	5178	40.28
			T - 1978 Plymouth Horizon	3008	
3051-8	03/05/79	Rear-end (Symmetric)	B - 1978 Chevrolet Caprice	4382	39.89
			T - 1978 Dodge Omni	3162	

*B = Bullet Vehicle; T = Target Vehicle

**Repaired truck from Test 3

4/15/79

TABLE 1-2. VEHICLE-TO-VEHICLE TEST CONDITIONS FOR AGGRESSIVITY ANALYSIS

Impact Configuration	Test Number	Test Date	Test Vehicle*	Test Weight (lb)	Closing Speed (mph)	Reference Source
Vehicle-to-subcompact size vehicle Head-on (Symmetric)	3051-1	10/10/78	B - 1979 Chevrolet C-10 Truck T - 1978 Plymouth Horizon	5180 2688	61.54	4
	C4-2	06/09/76	B - 1975 Ford Torino T - 1975 Honda Civic CVCC	2170 4430	59.46	9
Vehicle-to-full-size vehicle Head-on (Symmetric)	3051-2	10/12/78	B - 1979 Chevrolet C-10 Truck T - 1979 Chevrolet Impala	5182 4404	74.50	4
	C3-3	08/04/77	B - Fixed Barrier T - 1977 Chevrolet Impala	>100,000 3920	39.73	10
Vehicle-to-subcompact size vehicle 90° Left Side Impact	3051-3	10/23/78	B - 1979 Chevrolet C-10 Truck T - 1978 Plymouth Horizon	5189 2686	29.74	5
	M-5	07/17/74	B - 1968 Plymouth Fury T - 1974 Ford Pinto	ND ND	30.3	11
Vehicle-to-full-size vehicle 90° Left Side Impact	3051-4	11/17/78	B - 1979 Chevrolet C-10 Truck T - 1979 Chevrolet Impala	5183 4398	29.99	5
	3976-11	03/07/78	B - 1978 Chevrolet Impala T - 1976 Plymouth Volare	3914 4001	34.73	12

*B = Bullet Vehicle; T = Target Vehicle; ND = No Data Available

TABLE 1-2. VEHICLE-TO-VEHICLE TEST CONDITIONS FOR AGGRESSIVITY ANALYSIS (CONTD)

Impact Configuration	Test Number	Test Date	Test Vehicle*	Test Weight (lb)	Closing Speed (mph)	Reference Source
Vehicle-to-subcompact size vehicle Right Offset	3051-5	10/30/78	B - 1979 Chevrolet C-10 Truck	5183	61.62	6
			T - 1978 Plymouth Horizon	2682		
	C-3	12/15/77	B - 1978 Chevrolet Impala	3900	55.30	13
			T - 1976 Volkswagen Rabbit	2250		
Vehicle-to-full-size vehicle Right Offset	3051-6	11/28/78	B - 1979 Chevrolet C-10 Truck	5176	75.78	6
			T - 1979 Chevrolet Impala	4397		
	C-3	12/15/77	B - 1976 Volkswagen Rabbit	2250	55.30	13
			T - 1978 Chevrolet Impala	3900		
Vehicle-to-subcompact size vehicle Rear-end Impact	3051-7	02/01/79	B - 1979 Chevrolet C-10 Truck	5178	40.28	7
			T - 1978 Plymouth Horizon	3008		
	3051-8	03/05/79	B - 1978 Chevrolet Caprice	4382	39.89	8
			T - 1978 Dodge Omni	3162		

*B = Bullet Vehicle; T = Target Vehicle; ND = No Data Available.

1.3 ANALYSIS METHODOLOGY

The primary object of this study was to assess the aggressivity of light trucks in comparison to passenger car aggressivity. The assessment of light truck aggressivity was made by a comparative study of target vehicle performance under similar impact test conditions involving truck and car bullet vehicles. Since the testing on this program was primarily oriented toward developing a data base for the light truck impact, the test results from this program were compared with similar test results from other NHTSA-sponsored programs. However, it was generally not possible to find a previous crash test involving the same target vehicle model; therefore, target vehicles of a similar weight class were chosen as a basis for comparison.

From this data base two types of parameters were compared:

- Vehicle Parameters
    a. Compartment Velocity Change
    b. Maximum Compartment Acceleration
    c. Structural Crush
    d. Compartment Intrusion
    e. Fuel System Integrity
    f. Bumper Mismatch
- Occupant Parameters
    a. Head Injury Criteria (HIC)
    b. Head Resultant Acceleration
    c. Chest Severity Index (CSI)
    d. Chest Resultant Acceleration
    e. Femur Loads
    f. Ejection

In this fashion, an assessment of the relative aggressivity of light trucks was developed.

2.0 LIGHT TRUCK AGGRESSIVITY IN HEAD-ON COLLISIONS

2.1 STRUCTURAL PARAMETERS

The comparison Test C4-2 was chosen because the target vehicle was a subcompact car and the bullet vehicle was a full-size car, with the appropriate closing speed. The comparison Test C3-3 was chosen because it provided frontal head-on crash data for a full-size car with a similar velocity change.

A comparison of vehicle parameters for vehicle-to-subcompact car and vehicle-to-full-size car head-on impacts are presented in Tables 2-1 and 2-2, respectively. These two tables present data that is pertinent to assessing the bullet vehicles' structural aggressivity in that the parameters presented describe the structural response of the various vehicles.

For assessing possible architectural aggressivity, a comparison of the vehicle frontal geometries for the two test conditions are presented in Figures 2-1 and 2-2. Figure 2-3 illustrates the bumper interface for the Chevrolet C-10 truck and the Plymouth Horizon while Figure 2-4 shows the bumper interface for the Chevrolet C-10 truck-to-Chevrolet Impala impact. Additional parameters for assessing architectural aggressiveness in the various vehicles are presented in Table 2-3. This table compares bumper/engine dimensional parameters of the various vehicles.

A possible factor for evaluating mass aggressivity is the inertia force generated by the vehicle during impact. Inertia force can be approximated from compartment and engine data by:

TABLE 2-1. COMPARISON OF VEHICLE-TO-SUBCOMPACT CAR HEAD-ON COLLISIONS

	Test 3051-1		Test C4-2	
Vehicle Parameters	1979 Chevrolet C-10 Truck (B)	1978 Plymouth Horizon (T)	1975 Ford Torino (B)	1975 Honda Civic CVCC (T)
Overall Length/Width (in.)	217.0/78.0	163.2/66.2	217.5/79.3	150.0/59.3
Test Weight by Wheel (lb)	LF: 1364 RF: 1391 LR: 1199 RR: 1226	LF: 765 RF: 767 LR: 573 RR: 583	LF: ND RF: ND LR: ND RR: ND	LF: ND RF: ND LR: ND RR: ND
Test Weight (lb)	5180	2688	4430	2170
Wheelbase (in.)	131.5	99.4	118.0	86.8
Longitudinal C.G. (From Center of Front Axle) (in.)	61.6	42.7	ND	ND
Impact Angle (deg)*	0	180	0	180
Offset Distance (in.)	0	0	0	0
Car Speed (mph)	+30.8	+30.8	+29.73	+29.73
Final Speed (mph @ msec)	+4.3 @ 146	-11.7 @ 146	+0.6 @ 118	-12.7 @ 118
Velocity Change (mph)	26.5	42.5	28.9	42.4
Maximum Average Compartment Acceleration (G @ msec)	-26.1 @ 20	-41.1 @ 53	-15.9 @ 74	-36.0 @ 63
Maximum Engine Acceleration (G @ msec)	-26.1 @ 53	-86.7 @ 24	-40 @ 47	-170 @ 21
Maximum Mutual Dynamic Crush (Film Data) (in.)	58.1		ND	
Maximum Static Crush				
o Hood Level (in.)	6.2	19.6	ND	ND
o Between Hood/Bumper (in.)	16.6	26.2	ND	ND
o Front Bumper Level (in.)	21.1	20.5	20.5	22.7
Maximum Post-test Intrusion (in.)	2.0	9.6	0.0	7.7

*With respect to tow track centerline.
ND = No Data; B = Bullet; T = Target.

TABLE 2-2. COMPARISON OF VEHICLE-TO-FULL-SIZE CAR HEAD-ON COLLISIONS

	Test 3051-2		Test C3-3
Vehicle Data	1979 Chevrolet C-10 Truck (B)	1979 Chevrolet Impala (T)	1977 Chevrolet Impala (*)
Overall Length/Width (in.)	217.0/78.0	212.1/76.0	212.0/76.0
Test Weight by Wheel (lb)	LF: 1375 RF: 1379 LR: 1261 RR: 1167	LF: 1121 RF: 1100 LR: 1087 RR: 1096	LF: ND RF: ND LR: ND RR: ND
Test Weight (lb)	5182	4404	3920
Wheelbase (in.)	131.8	116.1	116.0
Longitudinal C.G. (From Center of Front Axle) (in.)	61.8	57.5	ND
Impact Angle (deg)**	0	180	0
Offset Distance (in.)	0	0	0
Car Speed (mph)	37.25	37.25	39.73
Final Speed (mph @ msec)	-0.3 @ 195	-10.1 @ 195	-6.4 @ 125
Velocity Change (mph)	37.52	47.35	46.13
Maximum Average Compartment Acceleration (G @ msec)	-27.1 @ 65	-42.6 @ 60	-44.5 @ 50
Maximum Engine Acceleration (G @ msec)	-97.8 @ 46	-91.9 @ 41	-100.5 @ 47
Maximum Mutual Dynamic Crush (Film Data) (in.)	87.3		ND
Maximum Static Crush			
o Hood Level (in.)	19.9	37.8	ND
o Between Hood/Bumper (in.)	27.9	35.6	ND
o Front Bumper Level (in.)	32.8	36.0	29.3
Maximum Post-test Intrusion (in.)	15.0	7.1	5.8

*Fixed Barrier test.
**With respect to tow track centerline.
ND = No Data; B = Bullet; T = Target.

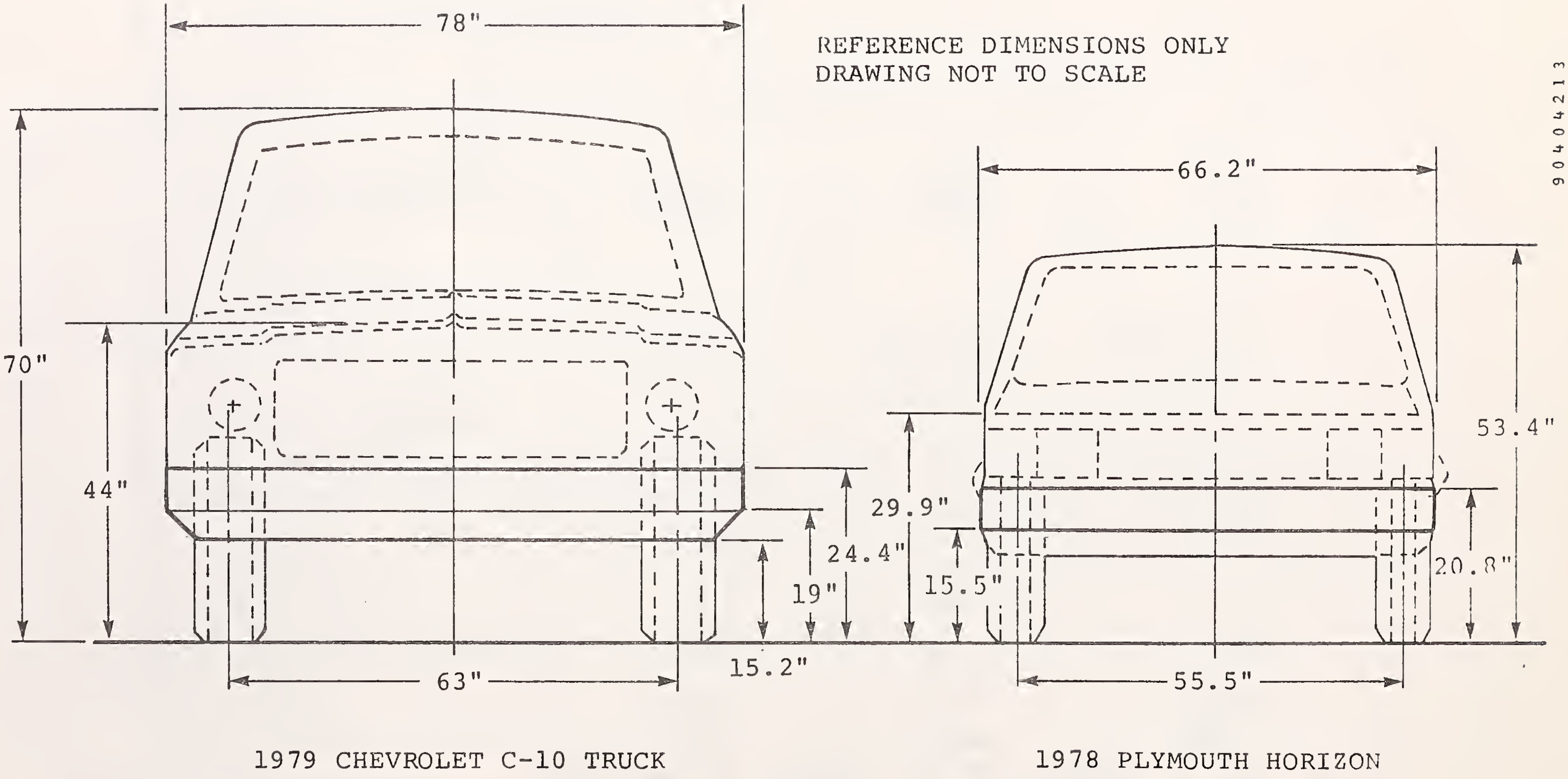
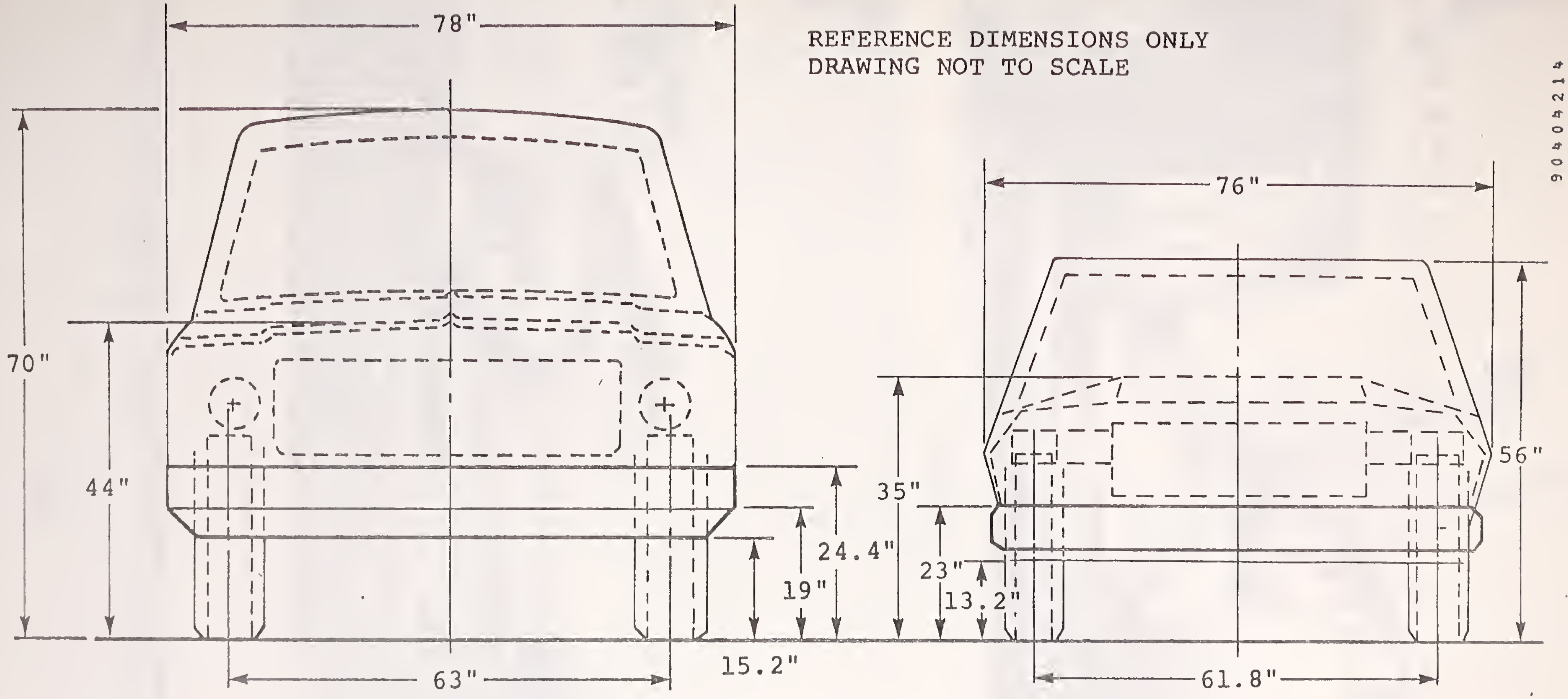


Figure 2-1. Chevrolet C-10 Truck/Plymouth Horizon Frontal Vehicle Geometry (Test 3051-1).

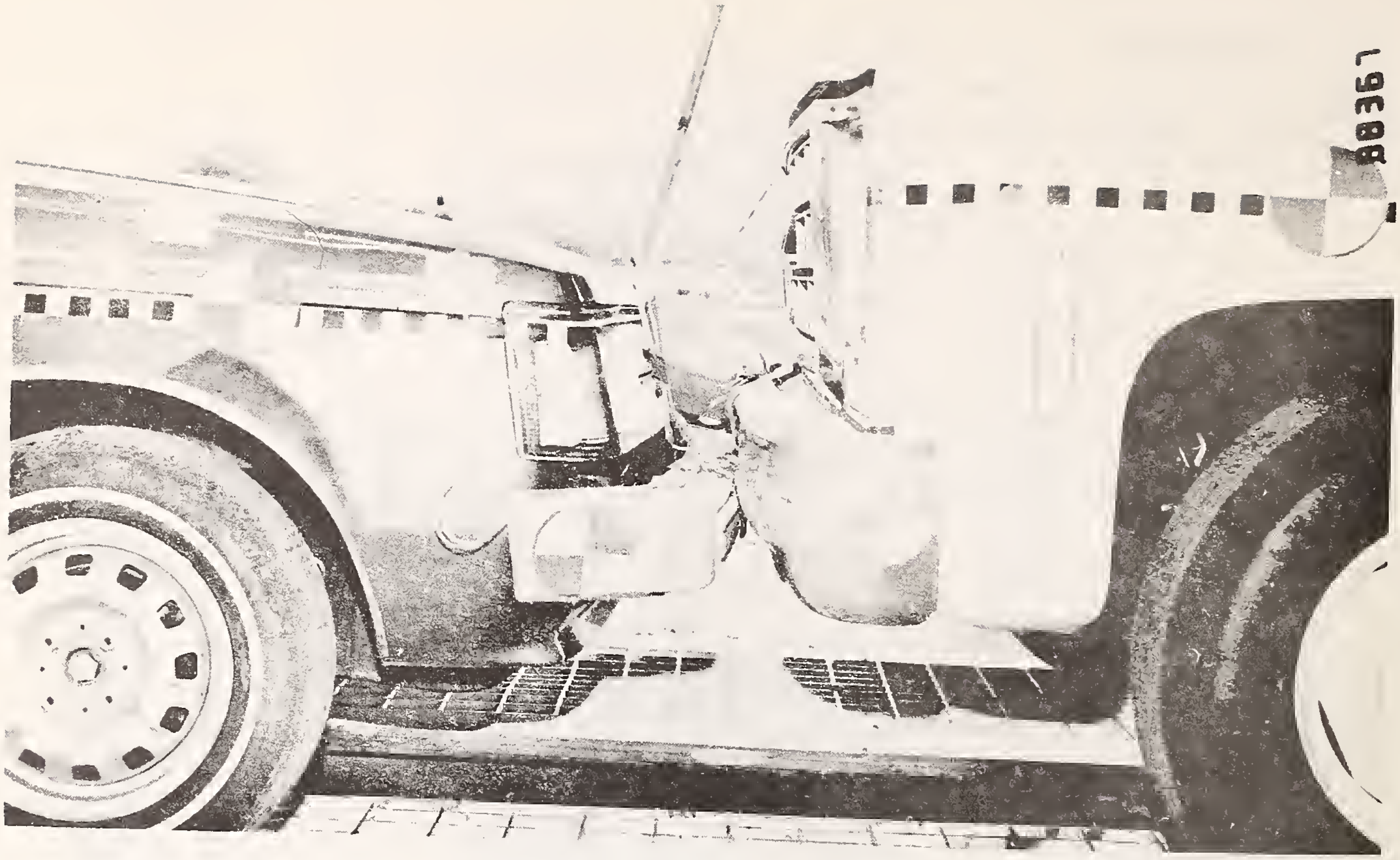


REFERENCE DIMENSIONS ONLY
DRAWING NOT TO SCALE

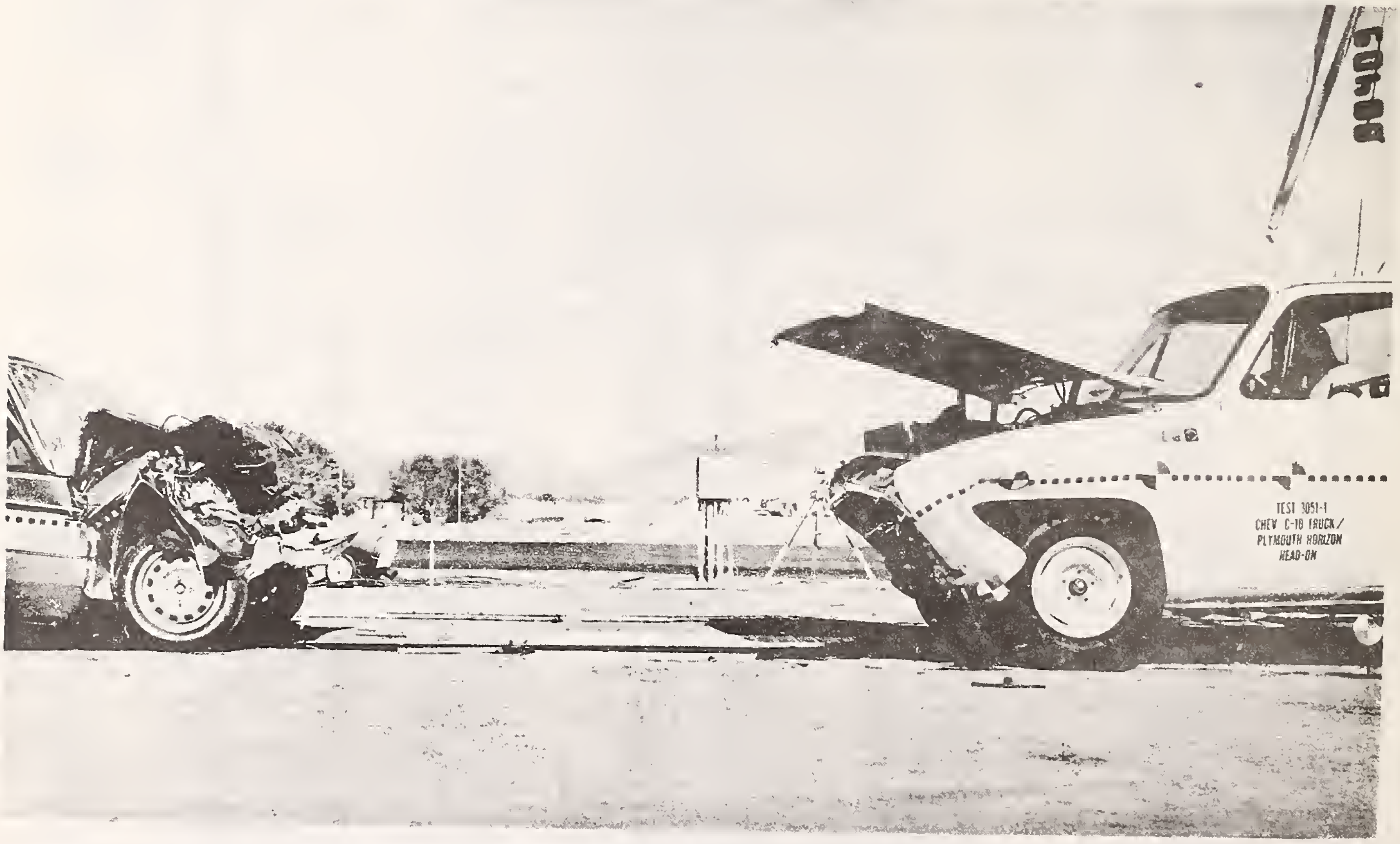
1979 CHEVROLET C-10 TRUCK

1979 CHEVROLET IMPALA

Figure 2-2. Chevrolet C-10 Truck/Chevrolet Impala Frontal Vehicle Geometry (Test 3051-2).

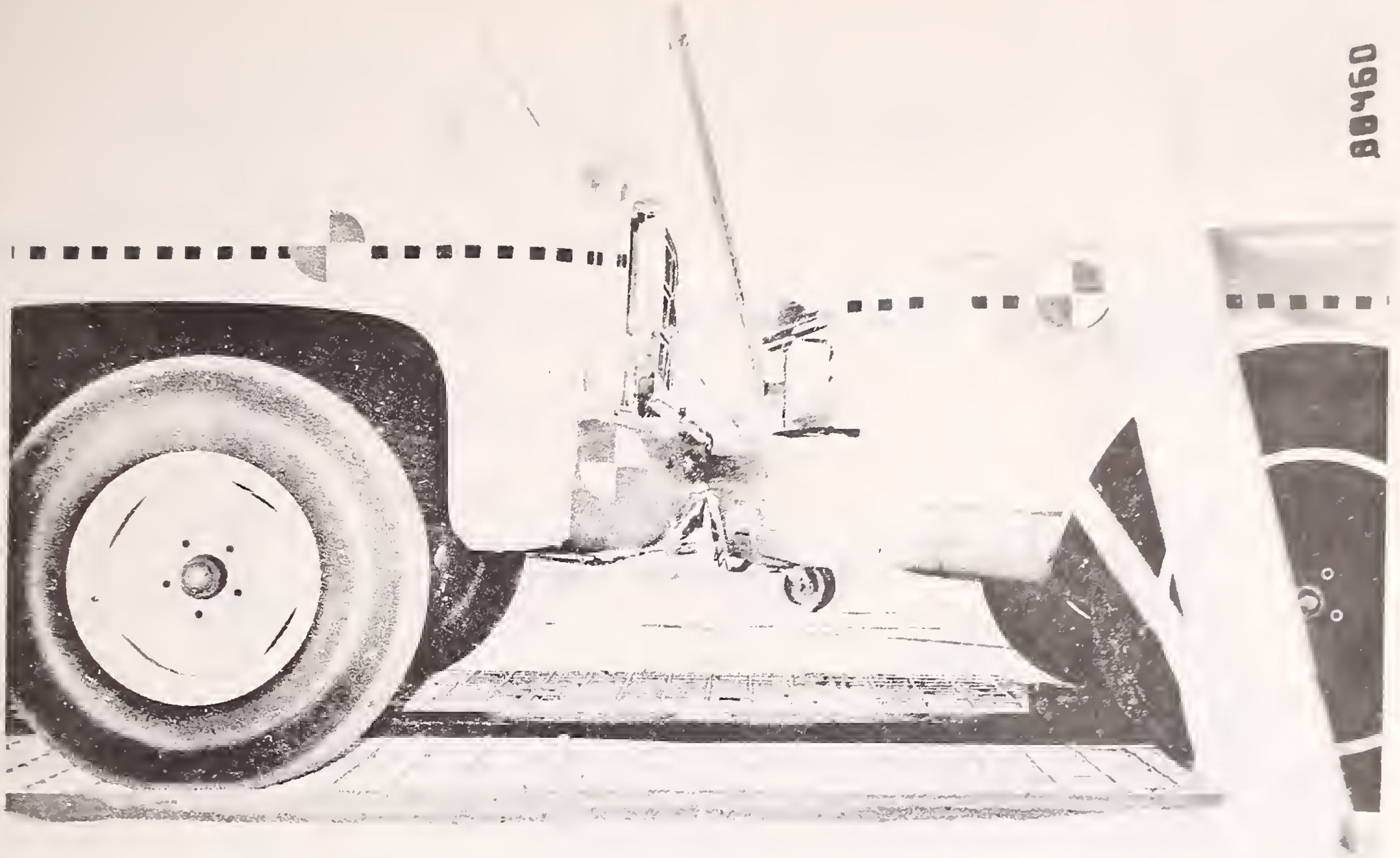


a) Pre-test

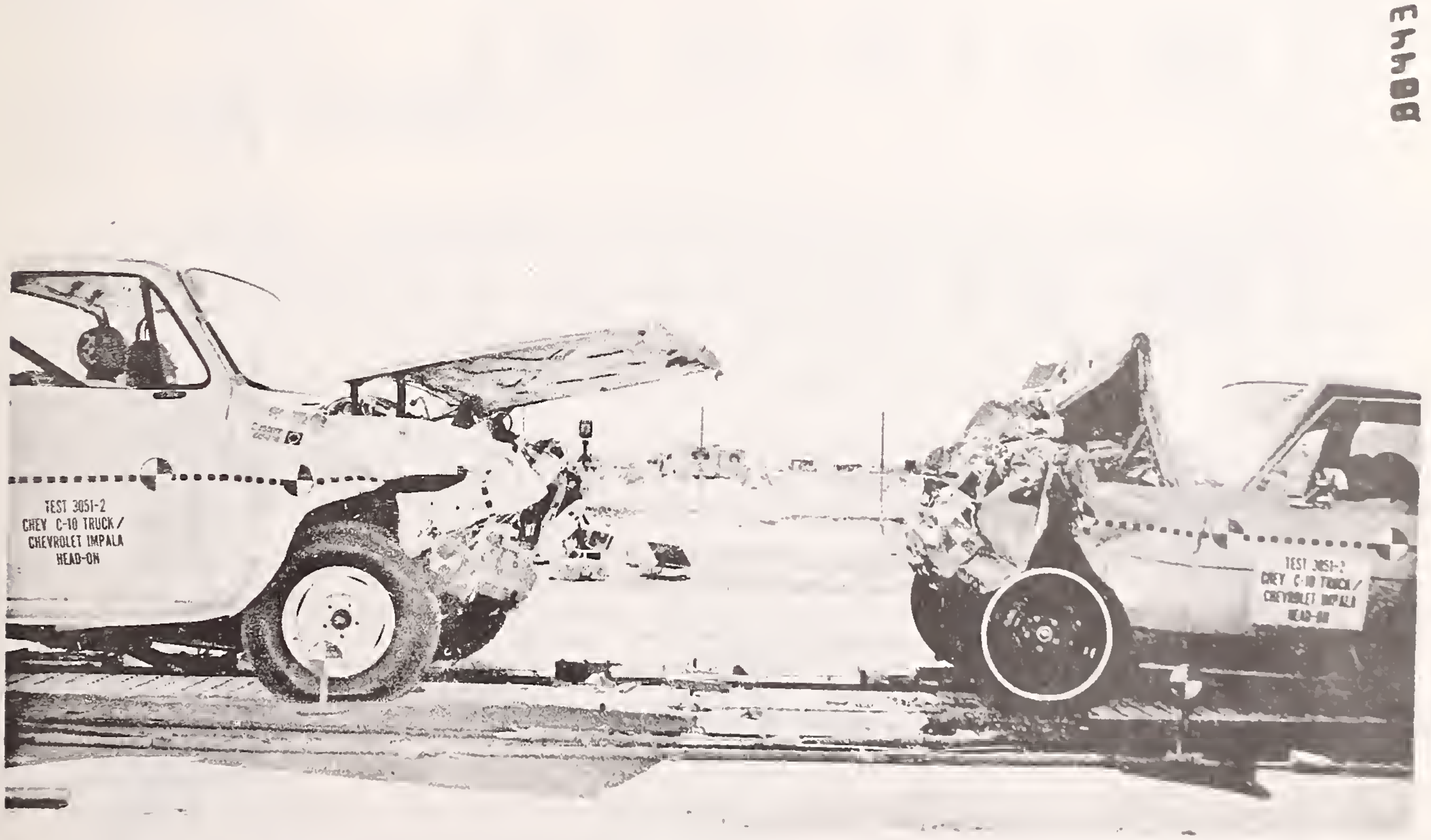


b) Post-test

Figure 2-3. Chevrolet C-10 Truck/Plymouth Horizon Bumper Matchup (Test 3051-1).



a) Pre-test



b) Post-test

Figure 2-4. Chevrolet C-10 Truck/Chevrolet Impala Bumper Matchup (Test 3051-2).

TABLE 2-3. BUMPER/ENGINE CHARACTERISTICS

	Test 3051-1		Test C4-2		Test 3051-2		Test C3-3
	1979 Chevrolet C-10 Truck	1978 Plymouth Horizon	1975 Ford Torino	1975 Honda Civic	1979 Chevrolet C-10 Truck	1979 Chevrolet Impala	1977 Chevrolet Impala
Engine Size (CID)	350	105	351*	90.8	350	350	ND
Engine Weight (lb)**	675	475	891*	305	675	675	ND
Engine Height (in.)	35.0	28.8	ND	ND	34.7	29.6	ND
Bumper to Engine (in.)	29.2	17.1	30.5	18.9*	28.8	34.8	ND
Hood Level Height (in.)	39.8	29.9	38.2	28.0*	39.6	31.2	40.5
Maximum Bumper Height (in.)	24.4	20.8	21.3	20.8*	24.1	23.0	ND
Minimum Bumper Height (in.)	15.2	15.5	13.3	16.8*	14.9	13.2	11.1*
Maximum Post-test Static Crush (in.)	21.1	26.2	20.5	22.7	32.8	37.8	29.3
Bumper Overide/ Underride	Override	Underride	Rotated Up	Pushed Back	Pushed Back	Pushed Back	Pushed Back

*Approximate - from MVMA specifications.
**Total dressed engine plus transmission.
ND = No Data Available.

$$F = (Ma)_{car} + (Ma)_{engine}$$

where F = inertia force

M_{car} = Mass of vehicle-engine mass

a_{car} = acceleration of vehicle

M_{engine} = mass of engine

a_{engine} = acceleration of engine

Figure 2-5 presents a comparison of the inertia forces for the Chevrolet C-10 truck and the Ford Torino. The inertia forces generated by the Plymouth Horizon and the Honda CVCC are shown in Figure 2-6 for reference. A comparison of the inertia forces for the C-10 truck and the two Chevrolet Impalas are presented in Figure 2-7.

2.2 OCCUPANT PARAMETERS

The primary parameters for assessing vehicle aggressivity are, of course, those related to target vehicle occupant response, since the primary goal is to reduce the potential for occupant injury. Table 2-4 presents a comparison of interior dimensions which indicate the interior stroking distances available for occupant deceleration. Also presented are test results indicating intrusion into the occupant compartment and occupant contacts with interior surfaces. The occupant response data measured in these symmetric head-on crash tests are presented in Table 2-5. Occupant ejection did not occur in any test, and therefore was not a significant comparison parameter.

2.3 COMPARATIVE EVALUATION

Comparing the data from the target vehicles in Table 2-1 (the Plymouth Horizon and Honda Civic), it appears that the Ford Torino is about as aggressive as the truck. If we compare

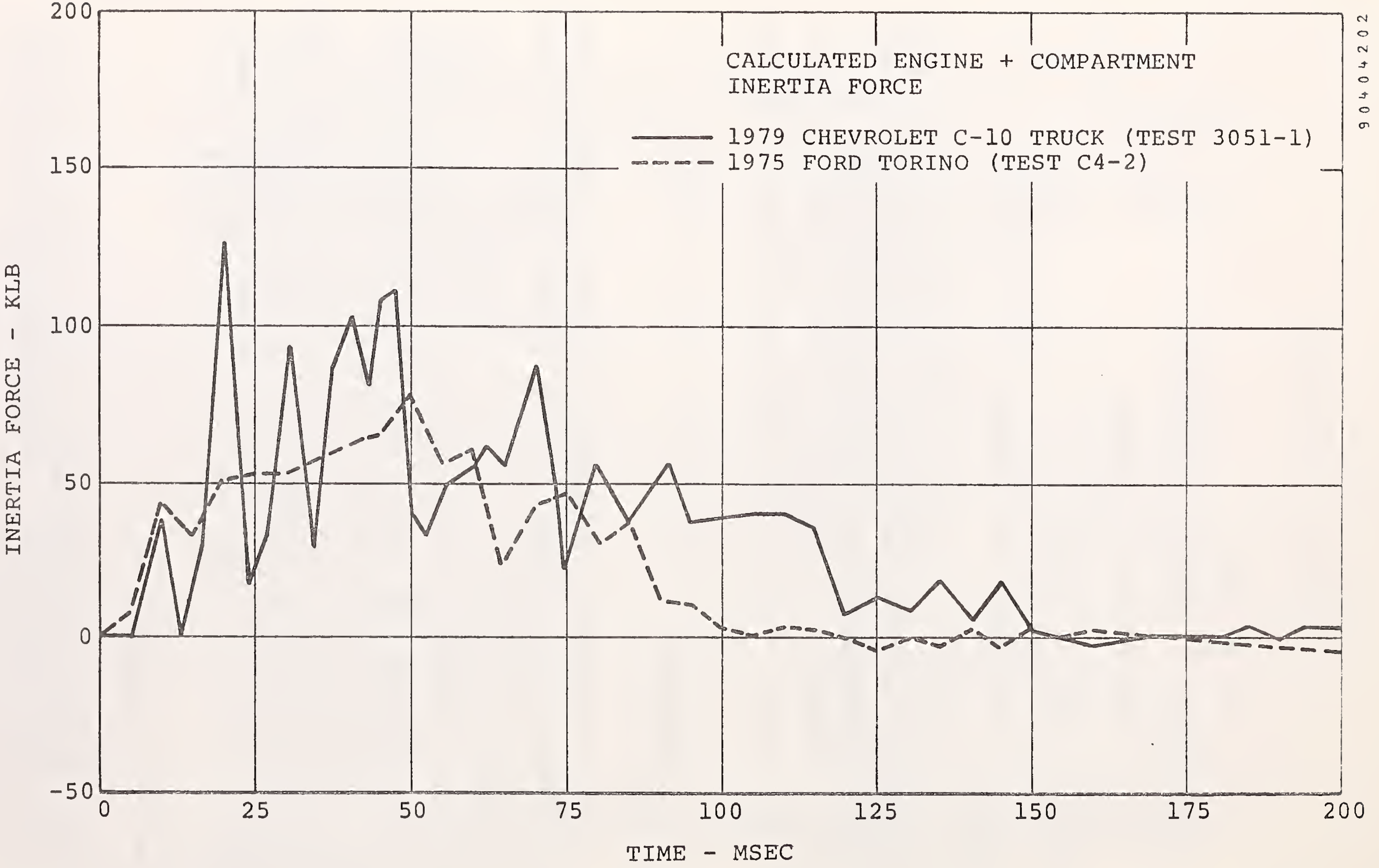


Figure 2-5. Chevrolet C-10 Truck/Ford Torino Inertia Force Comparison.

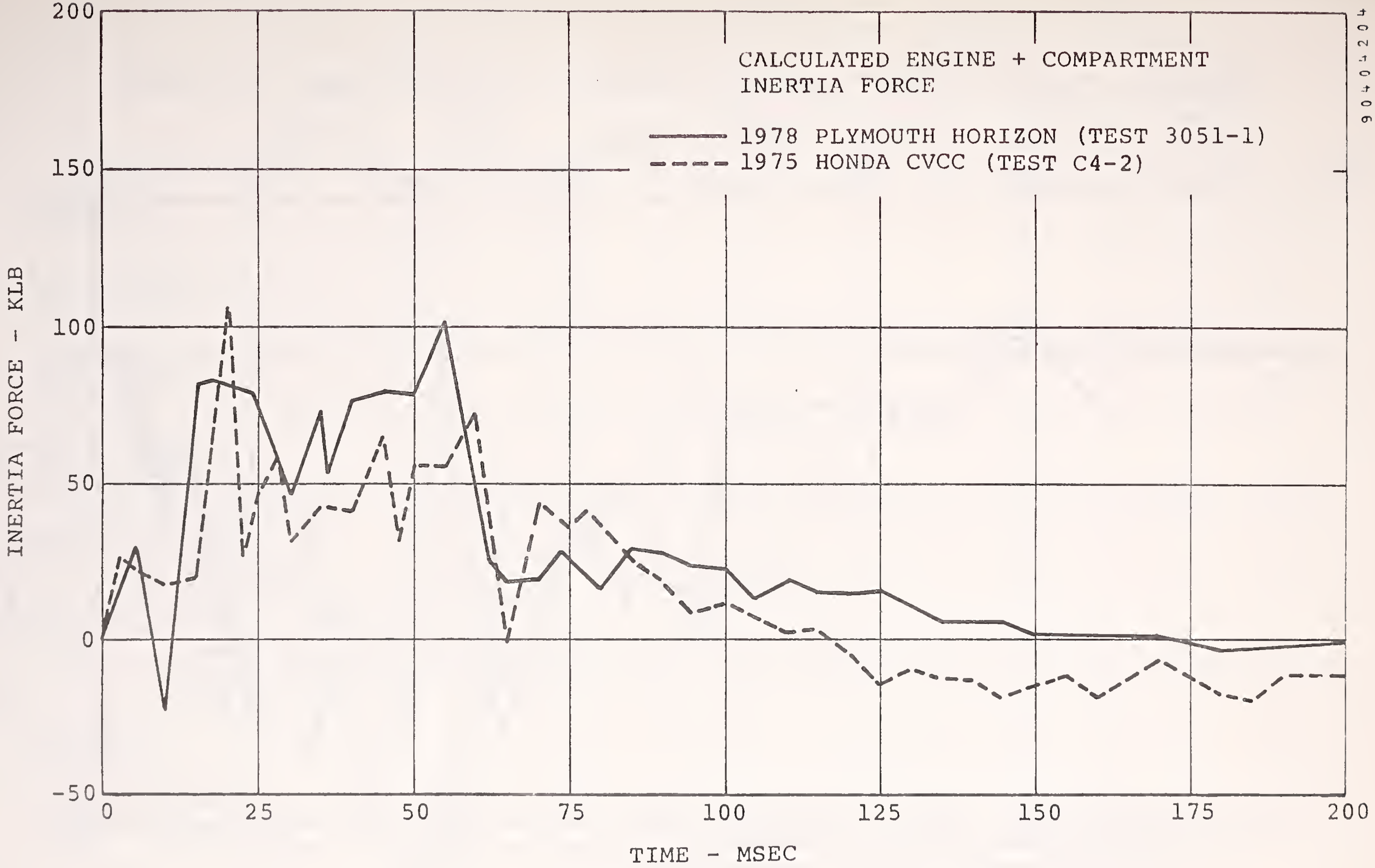


Figure 2-6. Plymouth Horizon/Honda CVCC Inertia Force Comparison.

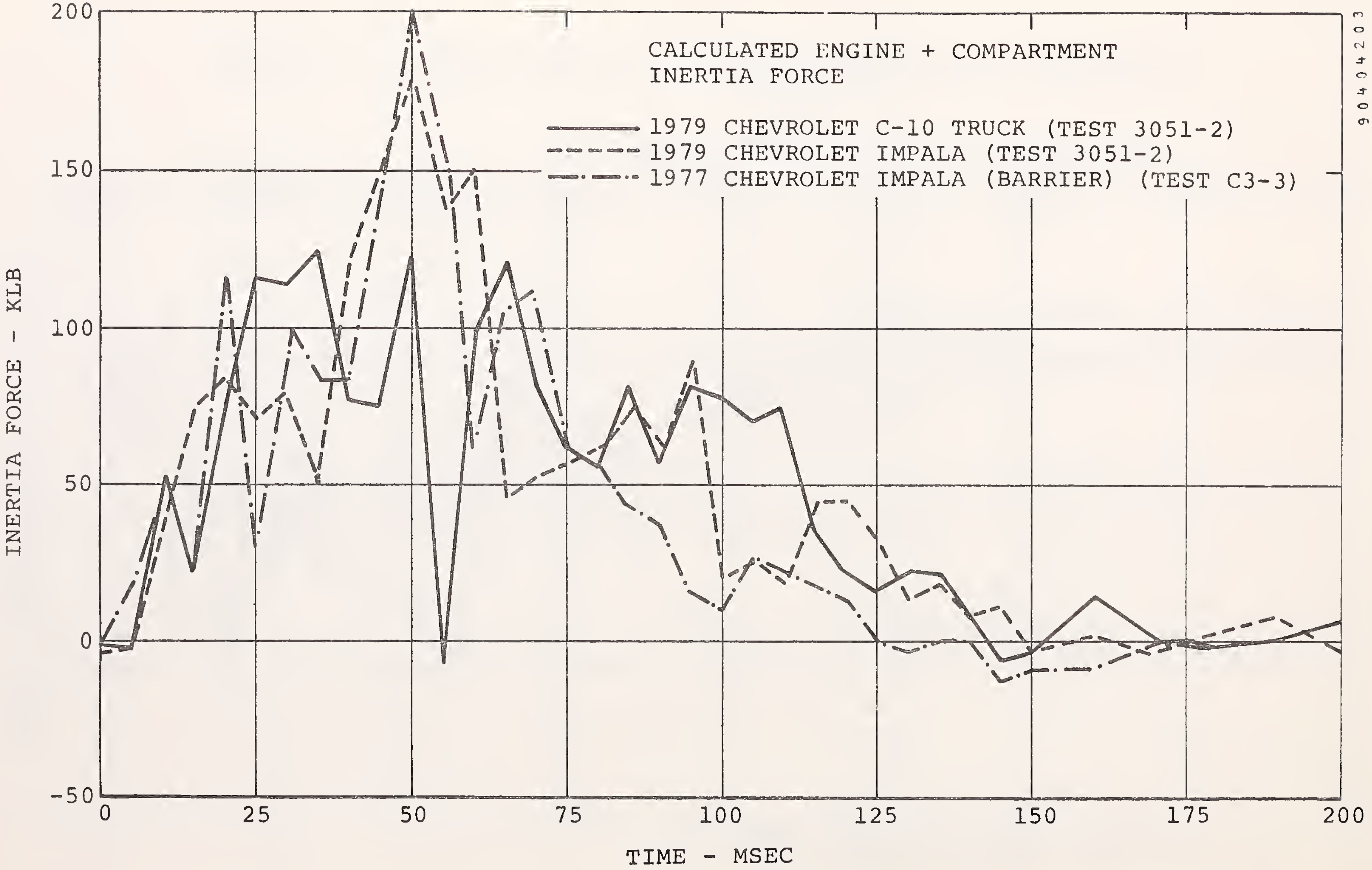


Figure 2-7. Chevrolet C-10 Truck/Chevrolet Impala Inertia Force Comparison.

TABLE 2-4. TEST VEHICLE OCCUPANT AVAILABLE STROKING DISTANCES

	Test 3051-1				Test C4-2				Test 3051-2				Test C3-3	
	1979 Chevrolet C-10 Truck		1978 Plymouth Horizon		1975 Ford Torino		1975 Honda Civic CVCC		1979 Chevrolet C-10 Truck		1979 Chevrolet Impala		1977 Chevrolet Impala	
Parameter	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF
Forehead to Header (in.)	17.9	19.0	13.3	13.9	12.5	12.5	11.6	11.6	19.0	20.8	14.9	15.7	51.1	15.1
Head to Windshield (Horizontal) (in.)	23.8	24.8	20.7	20.6	23.5	23.5	19.8	19.8	25.0	26.3	22.8	22.4	23.6	22.8
Chest to Dash Panel (Horizontal) (in.)	24.4	22.2	21.5	22.8	21.3	21.3	22.2	24.7	24.8	23.6	19.5	20.2	20.8	20.6
Nose-to-Upper Steering Wheel Rim (in.)	14.7	-	17.5	-	16.1	-	16.7	-	15.3	-	15.6	-	15.4	-
Chest to Steering Wheel Hub (in.)	10.9	-	15.6	-	10.7	-	10.8	-	11.2	-	12.6	-	11.1	-
Knee to Lower Panel (in.)														
Left	8.2	6.8	7.0	7.7	9.0	9.0	6.3	6.9	7.8	6.0	7.5	7.5	8.2	8.3
Right	8.3	7.3	7.6	7.5	9.0	9.0	6.3	6.9	7.9	6.6	7.2	7.6	8.2	8.3
Interior Intrusion	0.8	0.0	6.8	6.7	0.0	0.0	7.7	7.1	9.8	10.6	5.6	6.7	6.7	9.1
Occupant Contact With Compartment	Head Chest	None	Head Chest Knees	Head Knees	Head	None	Head Chest Knees	Head Knees	Head Chest Knees	Head Knees	Head Chest Knees	Head Knees	Head Knees	Head Knees

TABLE 2-5. SUMMARY OF OCCUPANT RESPONSE DATA - SYMMETRIC HEAD-ON CRASH TESTS

Occupant Response	Test 3051-1 1979 Chevrolet C-10 Truck		Test 3051-1 1978 Plymouth Horizon		Test C4-2 1975 Ford Torino		Test C4-2 1975 Honda Civic CVCC		Test 3051-2 1979 Chevrolet C-10 Truck		Test 3051-2 1979 Chevrolet Impala		Test C3-3 1977 Chevrolet Impala		FMVSS 208 Criteria
	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF	
HIC	385	ND	1030	3318	269	ND	1499	3103	1007	ND	2406	1543	1694	1045	<1000
Head Resultant (G)*	57.0	ND	92.2	201.6	45.1	ND	136	182	79.9	ND	127.2	99.1	110	66	None
CSI	175	ND	499	411	100	ND	830	530	852	ND	790	574	730	540	<1000
Chest Resultant (G)*	42.2	ND	51.0	44.7	30.7	ND	100	57	88.7	ND	63.4	47.7	65	44	<60 G
Femur Load (lb)															
Left	ND	ND	-525	-1283	ND	ND	2250	1100	ND	ND	-322	-1239	-650	-340	<2250 lb
Right	ND	ND	-739	-1875	ND	ND	800	1000	ND	ND	-1199	-1182	-260	-950	<2250 lb

*3 msec clip.
ND = No Data Available.

- Velocity Change
- Maximum Compartment Acceleration
- Maximum Static Crush - Bumper Level
- Maximum Post-test Intrusion

there does not appear to be a significant difference between the two target vehicles. Compartment acceleration was slightly higher for the Horizon; but the bumper level crush of the Civic was 2 inches more than the Horizon. A similar analysis of the data in Table 2-2 indicates the Chevrolet C-10 truck is slightly more aggressive than a barrier impact, primarily based on intrusion.

Examination of the occupant response data in Table 2-4 indicates the Honda Civic occupants faired much worse than the occupants of the Plymouth Horizon. It should be noted that the interior of the Honda is smaller than the Horizon (Table 2-4) and, of course, each vehicle has its unique restraint system. Thus, the apparent aggressivity of the truck could merely be a reflection of the differences in the target vehicles.

The Impala occupants in Test 3051-2 faired worse than the occupants in the barrier crash. Since the target vehicles (Chevrolet Impalas) are similar, the occupant data reinforces the conclusion that the Chevrolet truck is somewhat more aggressive than a car-to-barrier impact.

2.4 CONCLUSION

For symmetric head-on collisions, the factors which affect the aggressiveness of light trucks are primarily its overall mass and the height of its frontal contact area. The bumper to hood height being further off the ground tended to cause the greater occupant responses. This was due to the fact that the bumper of the truck did not completely engage the bumper of the struck vehicle, which caused more occupant intrusion. In comparison tests, the C-10 truck was generally about as aggressive as the Ford Torino and somewhat less aggressive than the Chevrolet Impala.

3.0 LIGHT TRUCK AGGRESSIVITY IN PERPENDICULAR SIDE IMPACTS

3.1 STRUCTURAL PARAMETERS

The vehicle response parameters for the four side impact tests examined are shown in Table 3-1. Tests M-5 and 3976-11 were chosen because the bullet vehicles were full-size cars. Better tests for comparison were not found in either NHTSA or Dynamic Science files. The data describes the structural response of the various vehicles used in assessing the structural aggressivity of the light truck.

Vehicle geometry differences between the vehicles used in the two light truck side impact test conditions are shown in Figures 3-1 and 3-2. The dimensional parameters used in determining the possible architectural aggressivity are presented in Table 3-2. Close-ups of C-10 truck bumper-to-vehicle side interface are shown in Figure 3-3 for Test 3051-3 and in Figure 3-4 for Test 3051-4.

The entry column for Test M-5 in Table 3-1 and for Tests 3976-11 and M-5 in Table 3-2 are included; however, as indicated, very little useful data was available from the published test reports. This limited the usefulness of these test results in the assessment of light truck aggressivity.

The inertia forces for the two vehicles in Test 3051-3, 3051-4, and 3976-11 are presented in Figures 3-5, 3-6, and 3-7, respectively. Interior dimensions for the bullet vehicles in these three tests are shown in Table 3-3. The definitions for these various dimensions are shown in Figure 3-8.

3.2 OCCUPANT PARAMETERS

Dimensional data for Tests 3051-3, 3051-4, and 3976-11, indicating the clearance between the dummy and the side structure, are shown in Table 3-4. The occupant response parameters for the three tests are presented in Table 3-5.

TABLE 3-1. COMPARISON OF VEHICLE-TO-VEHICLE 90° SIDE IMPACT COLLISION RESULTS

	Test 3051-3		Test M-5	
Vehicle Parameters	1979 Chevrolet C-10 Truck (B)	1978 Plymouth Horizon (T)	1968 Plymouth Fury (B)	1974 Ford Pinto (T)
Overall Length/Width (in.)	217.0/78.0	163.3/66.2	ND	ND
Test Weight by Wheel (lb)	LF: 1417 RF: 1336 LR: 1227 RR: 1209	LF: 782 RF: 716 LR: 649 RR: 539	ND ND	ND ND
Total Weight (lb)	5189	2686	ND	ND
Wheelbase (in.)	131.6	99.1	ND	ND
Longitudinal C.G. (From Center of Front Axle) (in.)	61.8	43.8	ND	ND
Impact Angle (deg)*	0	90	0	90
Offset Distance (in.)	0	83.9**	0	Door
Car Speed (mph)	+29.7	0	30.3	0
Final Speed (mph @ msec)	+18.5 @ 113	+19.6 @ 113	ND	ND
Velocity Change (mph)	11.2	19.6	ND	ND
Maximum Compartment Acceleration (G @ msec)	-17.3 @ 31	+19.2 @ 11	5	22.5
Maximum Engine Acceleration (G @ msec)	-12.2 @ 46	ND	ND	ND
Maximum Mutual Dynamic Crush (Film Data) (in.)	26.2		ND	
Maximum Static Crush				
o Hood Level (in.)	2.6		ND	
o Between Hood/Bumper (in.)	5.2		ND	
o Bumper Level (in.)	8.3		0.0	
o Window Sill		18.0		ND
o Middoor		17.6		ND
o Door Sill		13.5		ND
Maximum Post-test Intrusion (in.)	None	16.8	0.0	11.5

*With respect to tow track centerline.

**Distance from rear bumper (H-point of driver).

ND = No Data; B = Bullet; T = Target.

TABLE 3-1. COMPARISON OF VEHICLE-TO-VEHICLE 90° SIDE IMPACT COLLISION RESULTS (CONTD)

Vehicle Parameters	Test 3051-4		Test 3976-11	
	1979 Chevrolet C-10 Truck (B)	1979 Chevrolet Impala (T)	1978 Chevrolet Impala (B)	1976 Plymouth Volare (T)
Overall Length/Width (in.)	217.0/78.0	212.5/76.0	212.1/75.4	201.4/73.3
Test Weight by Wheel (lb)	LF: 1418 RF: 1347 LR: 1209 RR: 1209	LF: 1129 RF: 1105 LR: 1088 RR: 1076	ND ND	ND ND
Total Weight (lb)	5183	4398	3914	4001
Wheelbase (in.)	131.5	116.0	116.0	113.0
Longitudinal C.G. (From Center of Front Axle) (in.)	61.4	57.1	ND	ND
Impact Angle (deg)*	0	90	0	90
Offset Distance (in.)	0	111.9**	0	H-point of Driver
Car Speed (mph)	+30.0	0	34.7	0
Final Speed (mph @ msec)	+13.2 @ 146	+16.8 @ 146	+11.9 @ 163	18.0 @ 133
Velocity Change (mph)	16.8	16.8	22.8	18.0
Maximum Compartment Acceleration (G @ msec)	-15.8 @ 27	+22.1 @ 13	-22.0 @ 42	+35.6 @ 15
Maximum Engine Acceleration (G @ msec)	-15.2 @ 65	N/A	20.6 @ 52	N/A
Maximum Mutual Dynamic Crush (Film Data) (in.)	18.9		ND	
Maximum Static Crush				
o Hood Level (in.)	9.9		ND	
o Between Hood/Bumper (in.)	10.0		ND	
o Bumper Level (in.)	11.4		ND	
o Window Sill		13.9		ND
o Middoor		15.7		ND
o Door Sill		12.7		ND
Maximum Post-test Intrusion (in.)	0.9	15.6	ND	18.1

*With respect to tow track centerline.
**Distance from rear bumper (H-point of driver).
ND = No Data; B = Bullet; T = Target.

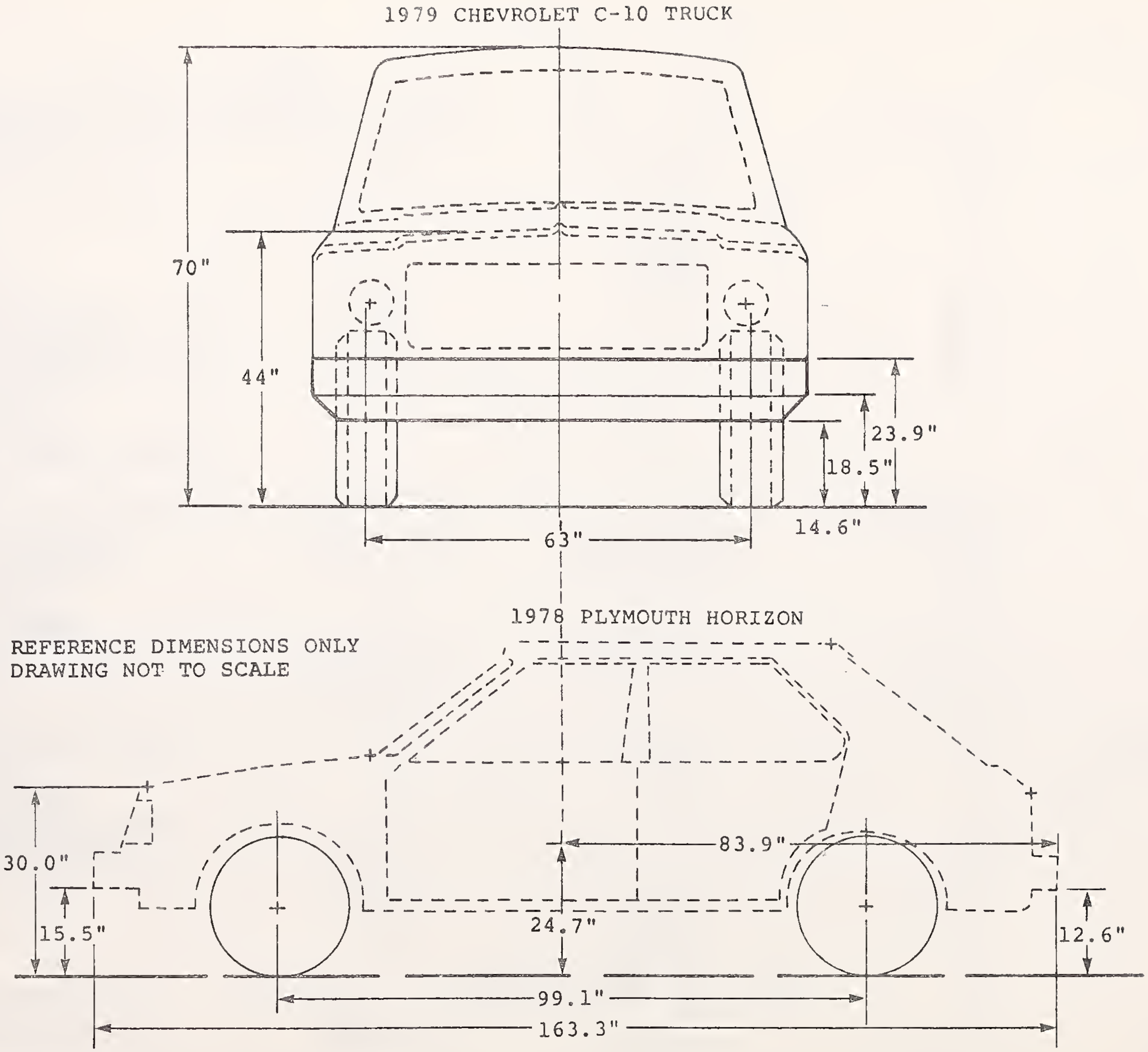


Figure 3-1. Chevrolet C-10 Truck/Plymouth Horizon Front/Side Vehicle Geometry (Test 3051-3).

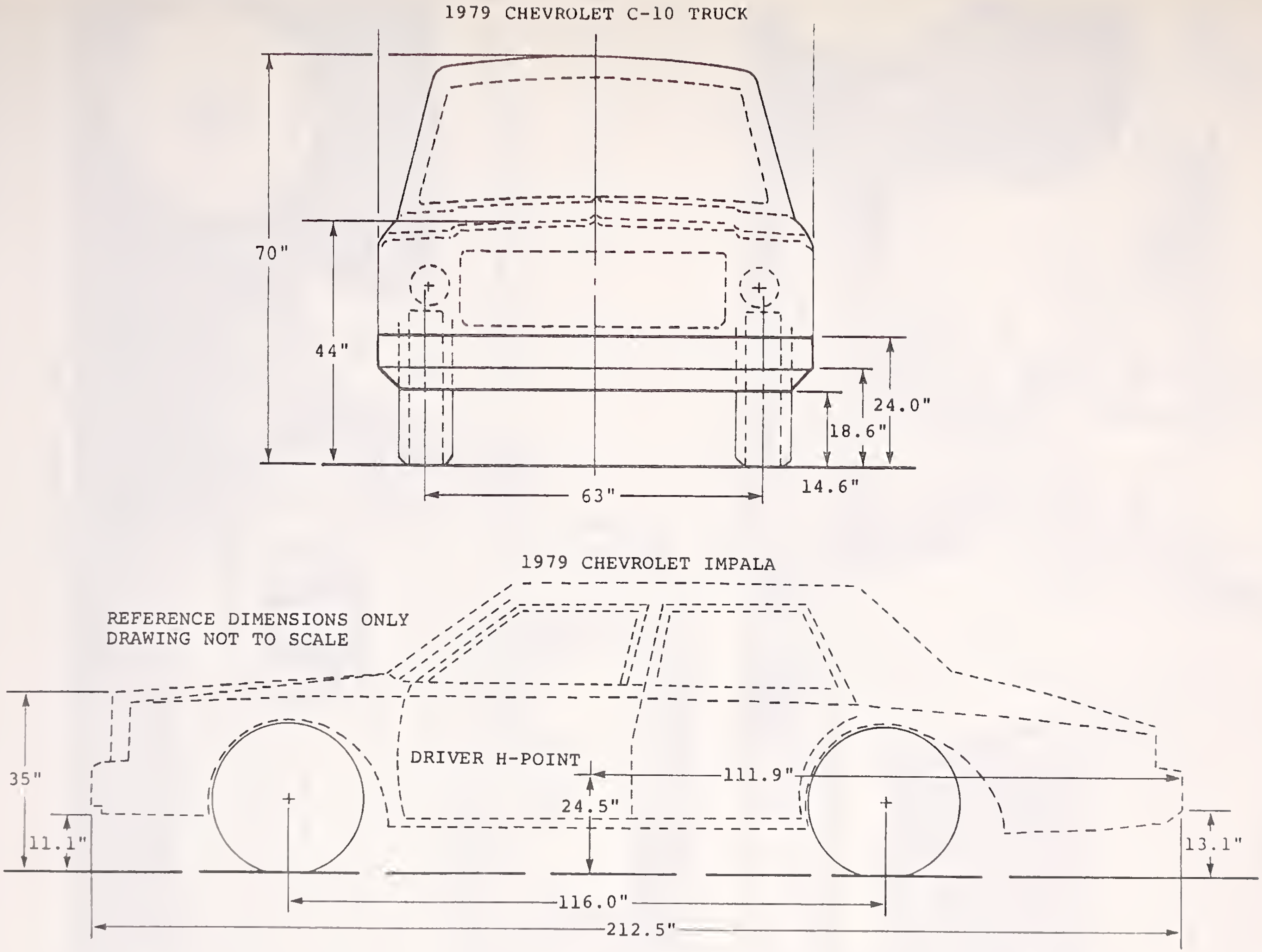
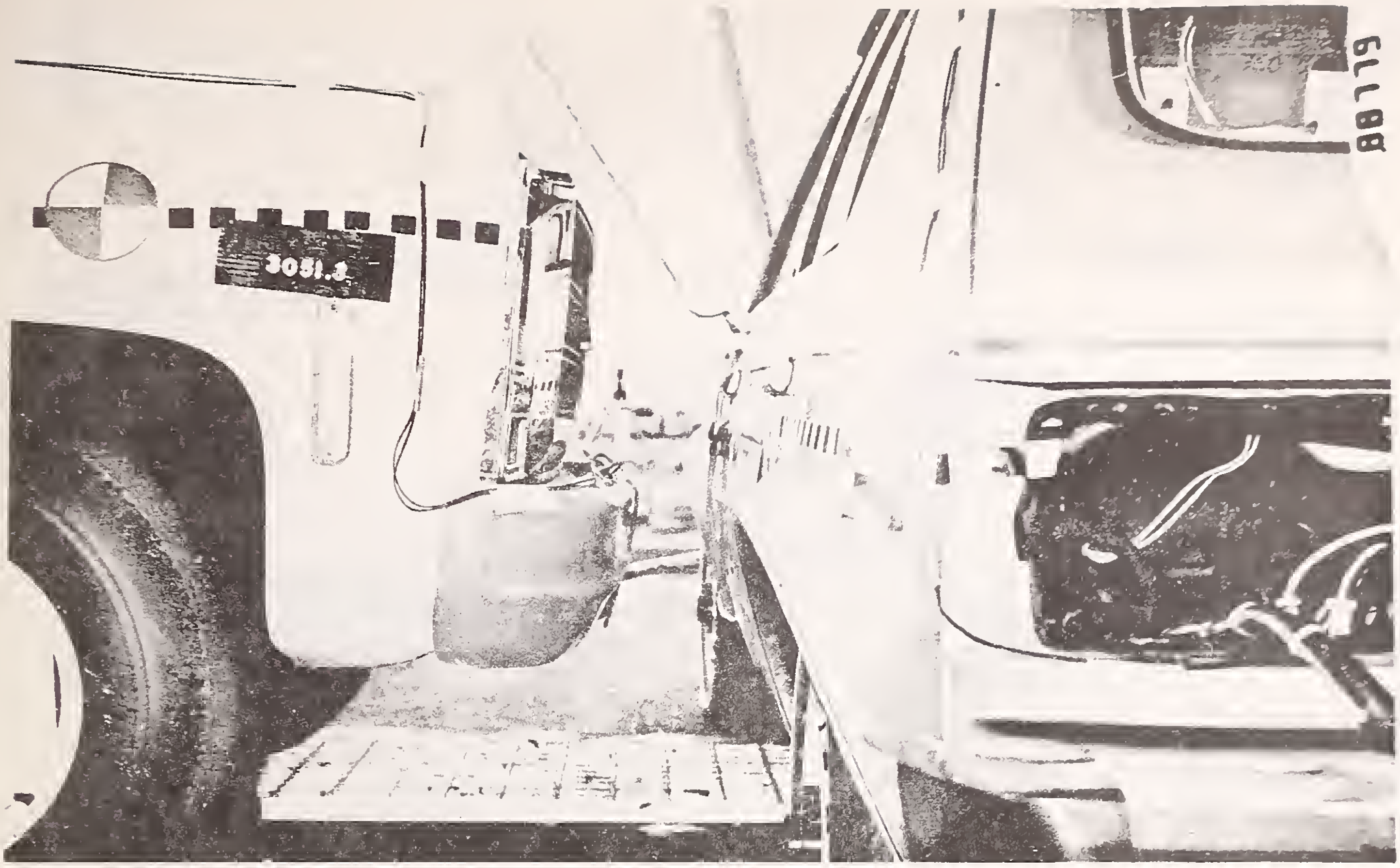


Figure 3-2. Chevrolet C-10 Truck/Chevrolet Impala Front/Side Vehicle Geometry (Test 3051-3).

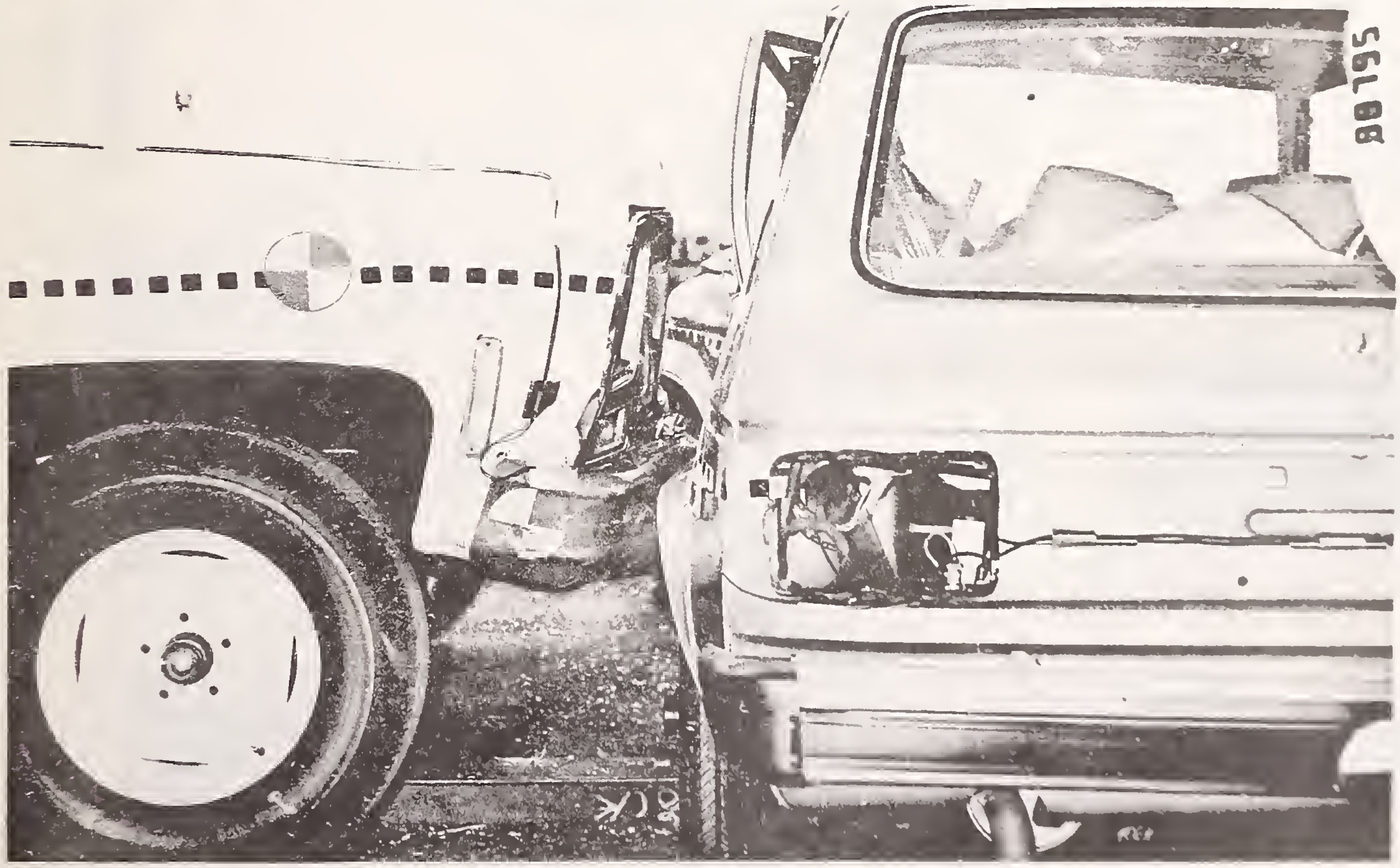
TABLE 3-2. BULLET VEHICLE BUMPER/ENGINE CHARACTERISTICS

	Test 3051-3 1979 Chevrolet C-10 Truck	Test 3051-4 1979 Chevrolet C-10 Truck	Test 3976-11 1978 Chevrolet Impala	Test M-5 1968 Plymouth Fury
Engine Size (CID)	350	350	305	ND
Engine Weight (lb)*	675	675	ND	ND
Engine Height (in.)	35.4	35.0	ND	ND
Bumper to Engine (in.)	29.5	28.9	ND	ND
Hood Level Height (in.)	39.0	39.2	ND	ND
Maximum Bumper Height (in.)	23.9	24.0	19.5	ND
Minimum Bumper Height (in.)	14.6	14.6	ND	ND
Maximum Static Crush (in.)	8.3	11.4	ND	ND

*Total dressed engine plus transmission.
ND = No Data Available.

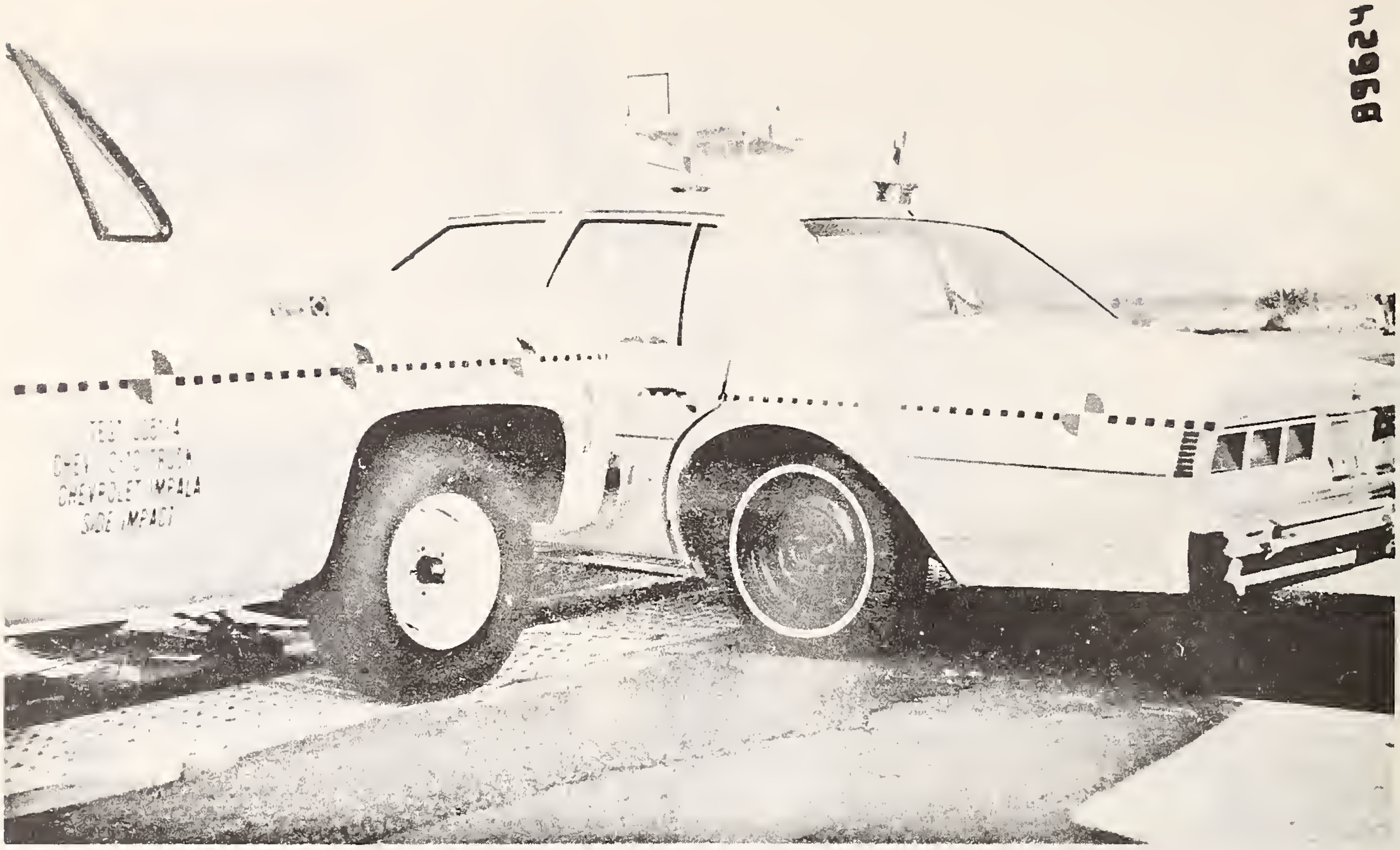


a) Pre-test

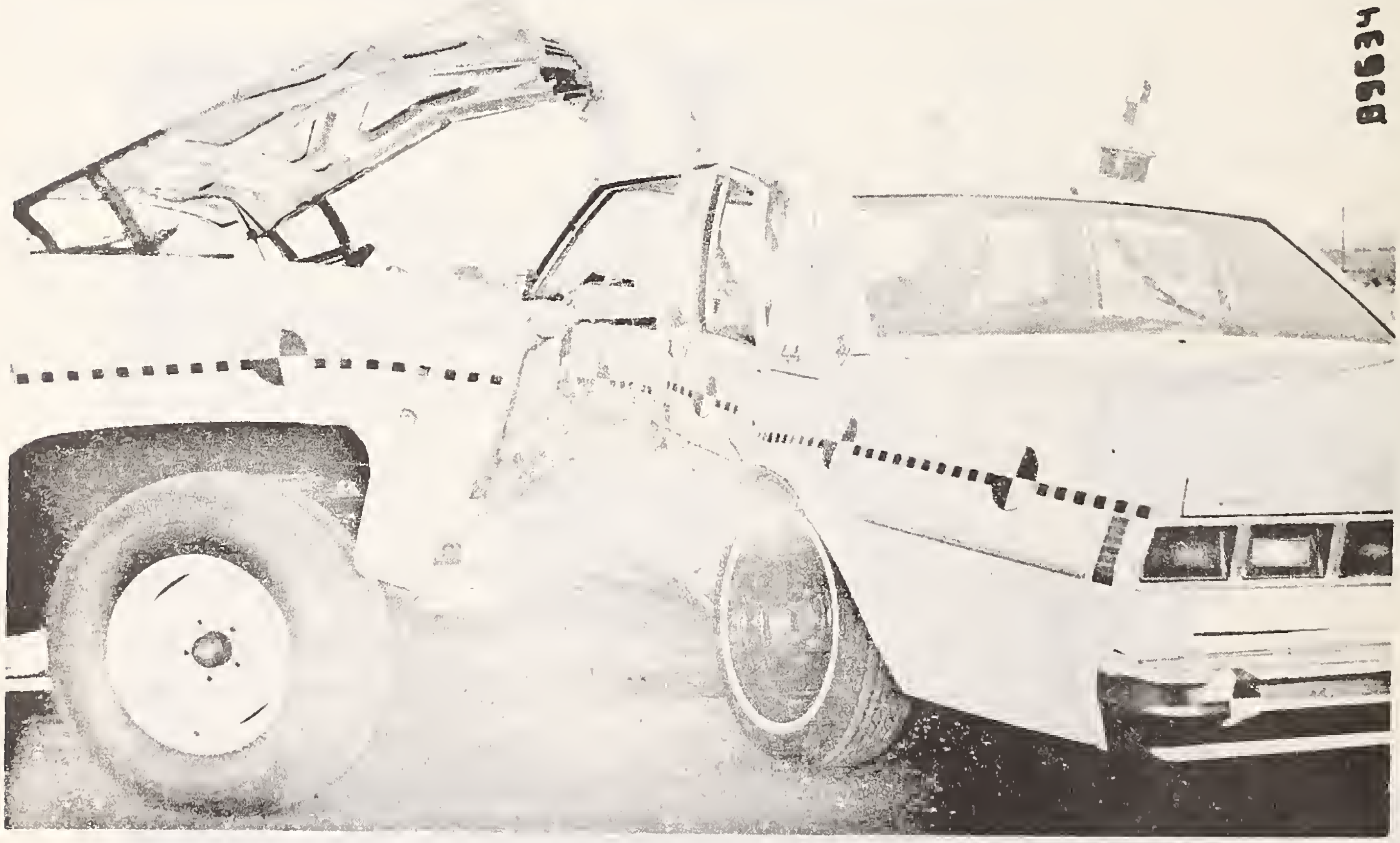


b) Post-test

Figure 3-3. Chevrolet C-10 Truck Bumper-to-Plymouth Horizon Side Matchup (Test 3051-3).



a) Pre-test



b) Post-test

Figure 3-4. Chevrolet C-10 Truck Bumper-to-Chevrolet Impala Side Matchup (Test 3051-4).

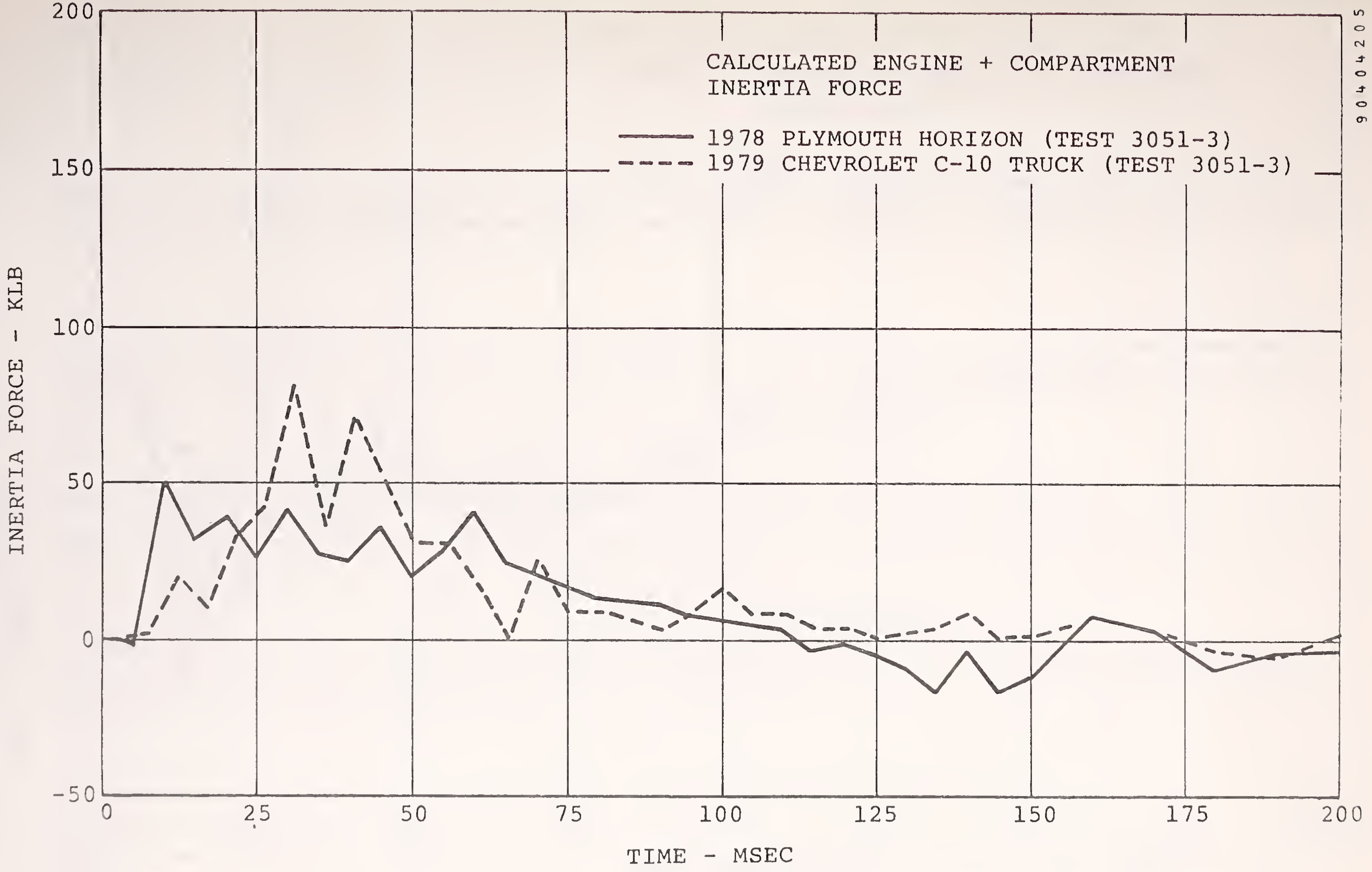


Figure 3-5. Chevrolet C-10 Truck/Plymouth Horizon Inertia Force Comparison.

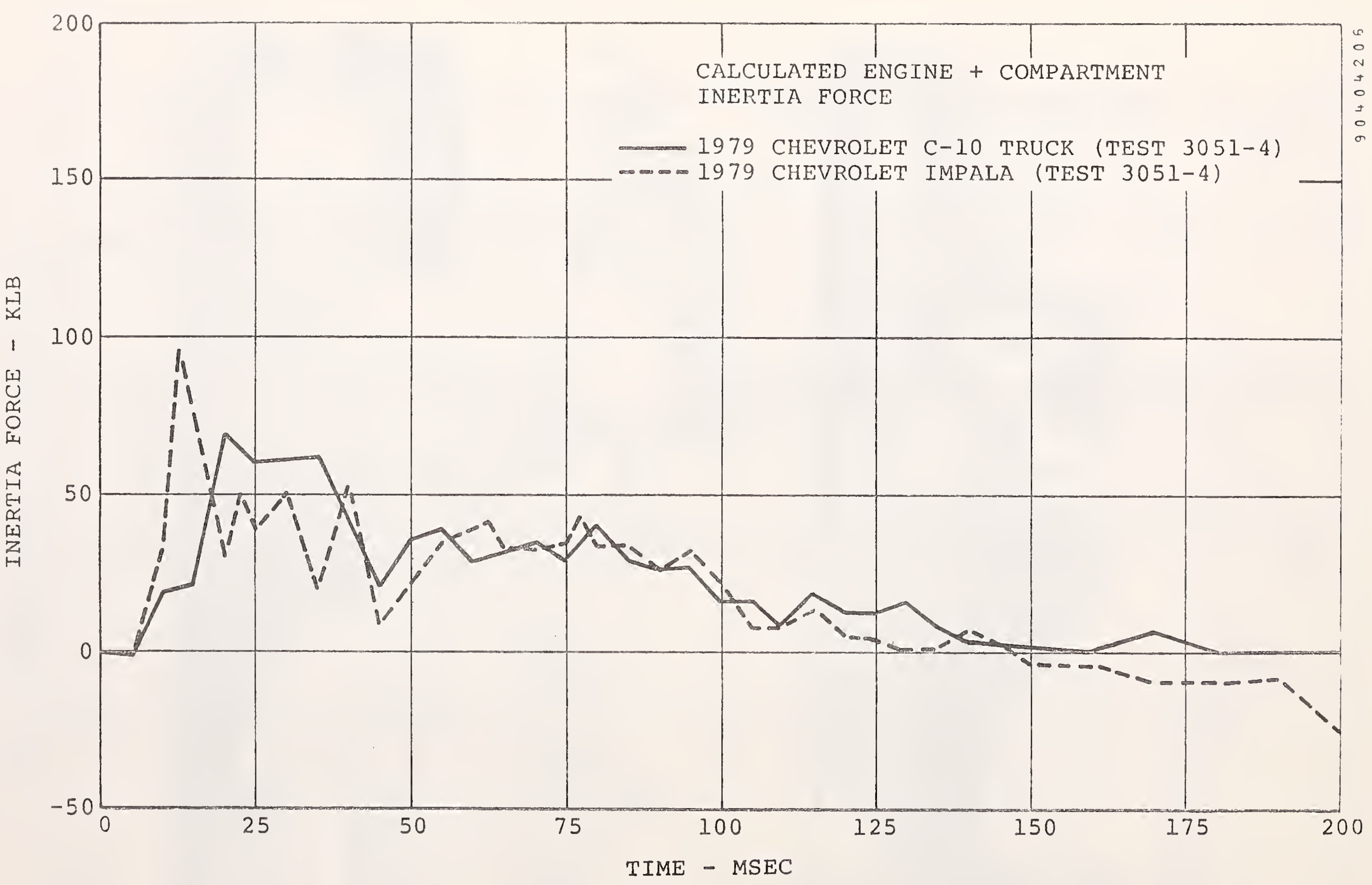


Figure 3-6. Chevrolet C-10 Truck/Chevrolet Impala Inertia Force Comparison.

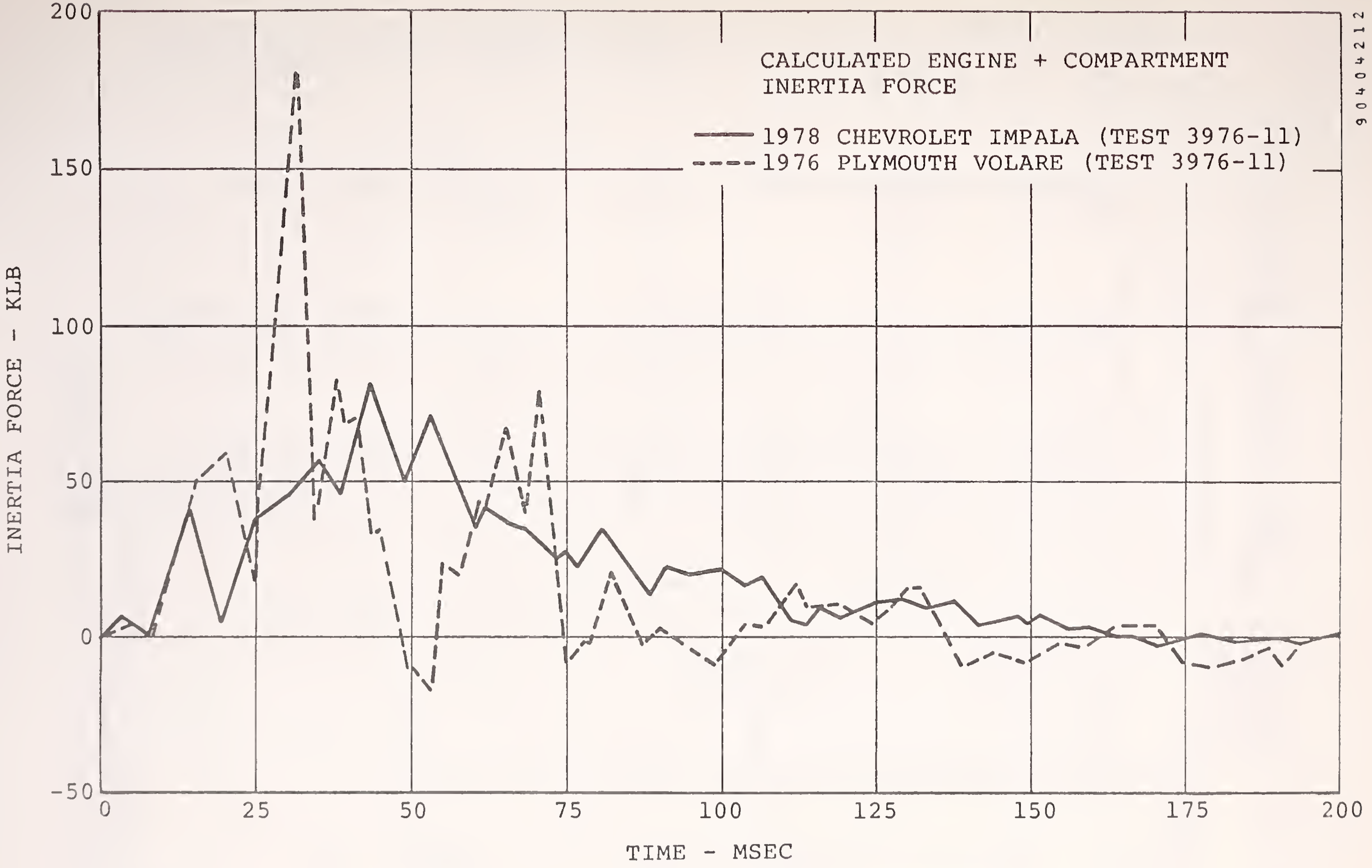


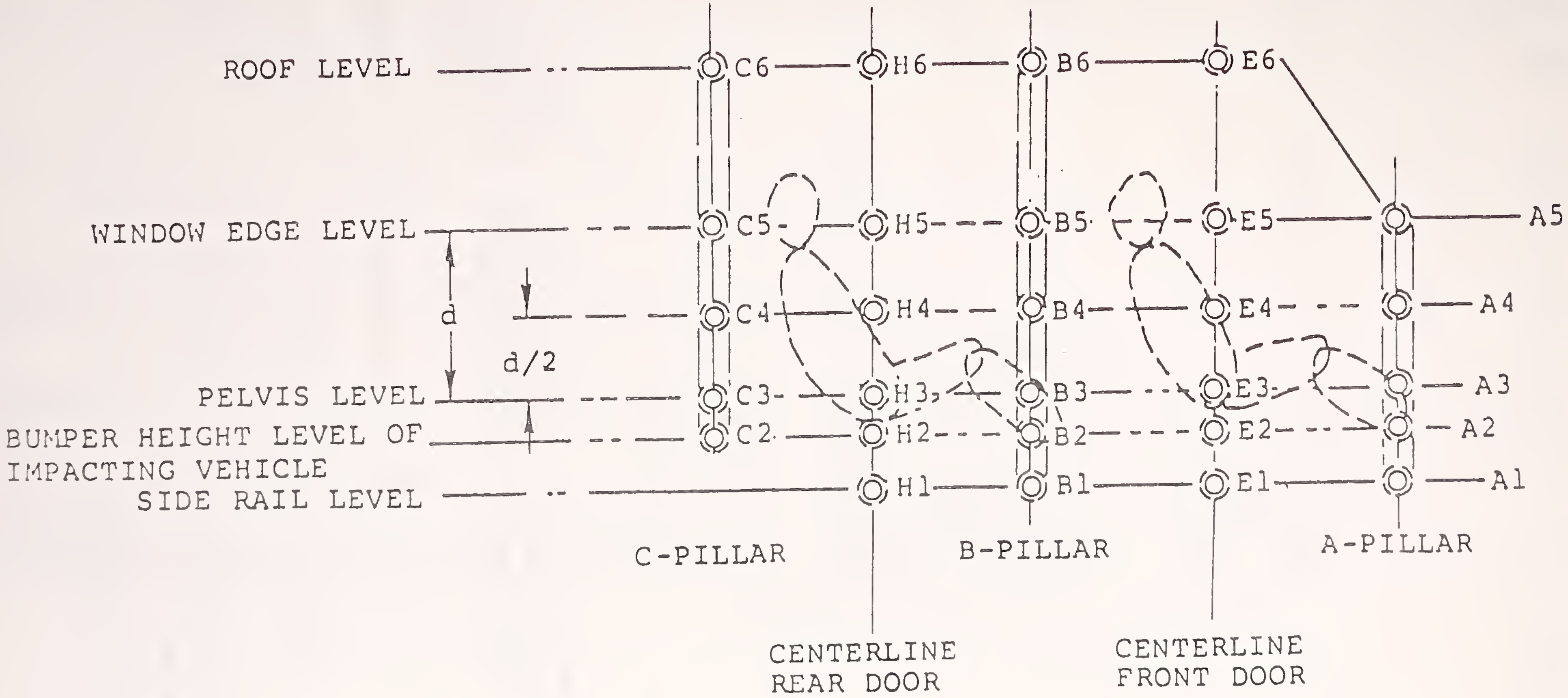
Figure 3-7. Chevrolet Impala/Plymouth Volare Inertia Force Comparison.

TABLE 3-3. COMPARISON OF STATIC INTERIOR INTRUSION FOR VEHICLE-TO-VEHICLE 90° SIDE IMPACT COLLISIONS

Static Crush (in.)		Location**				
Test 3051-3 1978 Plymouth Horizon	Level*	C	H	B	E	A
Roof	6	2.1	3.2	5.3	4.6	-
Window Edge	5	2.6	11.0	16.8	10.1	7.2
Middoor	4	1.8	11.2	16.6	11.1	10.4
H-Point	3	1.4	10.5	15.7	13.5	9.8
Bumper	2	1.1	8.3	14.7	12.4	9.9
Sill Rail	1	-	7.6	14.1	11.4	8.5
Test 3051-4 1978 Chevrolet Impala	Level*					
Roof	6	3.9	6.1	6.7	4.6	-
Window Edge	5	5.0	12.8	11.5	8.8	4.4
Middoor	4	7.2	11.6	13.3	9.5	6.3
H-Point	3					
Bumper	2	8.1	11.5	15.6	10.3	8.2
Sill Rail	1	6.2	7.8	11.0	10.0	7.0
Test 3976-11 1976 Plymouth Volare	Level*					
Roof	6	0.8	2.8	4.1	3.5	-
Window Edge	5	7.1	9.8	13.1	7.3	4.0
Middoor	4	9.4	10.8	13.9	10.4	4.6
H-Point	3	-	11.8	16.4	11.9	5.6
Bumper	2	-	12.0	18.1	11.6	6.3
Sill Rail	1	-	12.4	14.6	11.9	6.6

*Defined according to Figure 3-8.
**Distance for Reference Plane 2 inches right of right front and right rear axle hubs on right side of vehicle.

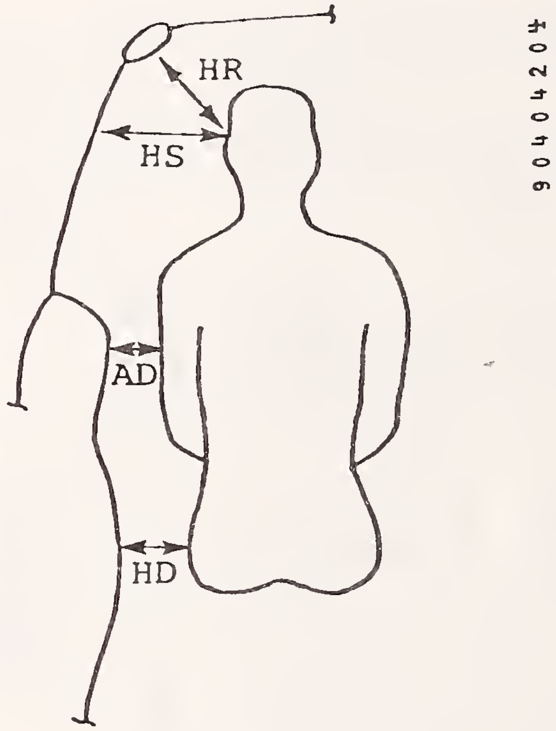
MAXIMUM OCCUPANT COMPARTMENT INTRUSION WAS MEASURED RELATIVE TO AN UNDISTURBED VEHICLE REFERENCE LINE.



O LOCATIONS AT WHICH INTRUSION MEASUREMENTS WERE MADE

Figure 3-8. Intrusion Measurement Locations.

TABLE 3-4. DUMMY POSITIONING DATA FOR VEHICLE-TO-VEHICLE 90° SIDE IMPACT COLLISION



Measurement	Test 3051-3 (Plymouth Horizon) Front/Rear	Test 3051-4 (Chevrolet Impala) Front/Rear	Test 3976-11 (Plymouth Volare) Front/Rear
Head to door glass (HS)	9.2/7.2	12.0/12.1	8.8*/7.8
Head to side header (HR)	7.2/7.5	8.7/10.8	ND/ND
Upper arm to door panel (AD)	3.1/3.3	6.0/7.7	14.8*/15.0*
H-point to door panel (HD)	4.8/6.0	9.1/7.7	ND/ND

*Measured from dummy centerline.
ND - No Data.

TABLE 3-5. SUMMARY OF OCCUPANT RESPONSE DATA FOR 90° SIDE IMPACT COLLISIONS

	Test 3051-3				Test 3051-4				Test 3976-11				
	1979 Chevrolet C-10 Truck (B)		1978 Plymouth Horizon (T)		1979 Chevrolet C-10 Truck (B)		1979 Chevrolet Impala (T)		1978 Chevrolet Impala (B)		1976 Plymouth Volare (T)		
Occupant Response	LF	RF	LF	LR	LF	RF	LF	LR	LF	RF	LF	RF	FMVSS 208 Criteria
HIC	26.8	ND	581	453	489	ND	172	202	150	126	201	144	<1000
Head Resultant (G)*	14.0	ND	83.1	75.0	78.2	ND	49.6	50.0	31	29	52	47	None
CSI	21	ND	577	158	47	ND	309	165	94	84	198	336	<1000
Chest Resultant (G)*	12.8	ND	70.2	43.2	18.8	ND	77.9	45.3	27	27	41	60	<60 G
Femur Load (lb)													
Left	ND	ND	+225	-830	ND	ND	+192	-292	+423	+679	ND	ND	<2250 lb
Right	ND	ND	+483	ND	ND	ND	-287	+316	+468	+294	ND	ND	<2250 lb

*3 msec clip.

ND = No Data Available; B = Bullet; T = Target.

3.3 COMPARATIVE EVALUATION

By comparing the vehicle parameters for the Chevrolet Impala in Test 3051-4 with those for the Plymouth Volare in Test 3976-11, from Table 3-1, it appears that the Impala/Volare test is slightly more severe than the C-10 truck. The parameters

- velocity change
- compartment acceleration
- static crush
- post-test intrusion

are all higher for the Volare than for the Impala for the two comparison tests. However, this may be partly due to the higher impact velocity for Test 3976-11. Examination of the target vehicle occupant response data, however, reveals some significant differences between the target vehicles (Chevrolet Impala and Plymouth Volare) for Tests 3051-4 and 3976-11. In some cases (head data), the injury criteria for the Chevrolet Impala in Test 3051-4 are higher than those for the Volare in Test 3976-11 while in other cases (chest data), the opposite is true. These differences may reflect differences in car interior restraint systems and not necessarily the relative aggressivity of the bullet vehicles.

3.4 CONCLUSION

Since the target vehicles in the comparisons were not identical, it is difficult to provide a reliable assessment of the relative aggressivity of the truck with respect to a typical passenger car. However, it can be observed that the target driver head and chest response in truck side collisions is much higher than that for the Chevrolet-Volare collision, even though the impact speed was 5 mph lower. This suggests that the light truck is more aggressive than a typical passenger car in side impact.

The frontal areas of the Impala and truck are similar, but the truck bumper is higher from the ground and would influence driver dummy response. In order to assess this, it is recommended that a Chevrolet Impala-to-Plymouth Horizon side impact test be conducted to provide an exact comparison test for this critical crash environment.

4.0 LIGHT TRUCK AGGRESSIVITY IN FRONTAL RIGHT OFFSET COLLISIONS

4.1 STRUCTURAL PARAMETERS

Vehicle response parameters for two sets of vehicle right offset collisions are presented in Tables 4-1 and 4-2. The same test (Test C-31) is shown in both tables for the comparison since it was the only Impala offset test that could be found in the published data; however, the primary comparison for assessing light truck aggressivity for vehicle parameters is based upon the small car data in Table 4-1. It should be noted that the closing speed for Test C-31 (55.4 mph) was considerably less than for Test 3051-5 (61.6 mph) and for Test 3051-6 (75.8 mph).

Bumper matchups for Test 3051-5 and Test 3051-6 are shown in Figures 4-1 and 4-2, respectively. Refer to Figures 2-1 and 2-2 for vehicle geometry differences which are applicable to front offset collisions also. Bumper/engine dimensional parameters are presented in Table 4-3.

The inertia forces for the three offset tests are shown in Figures 4-3, 4-4, and 4-5, respectively. These figures illustrate the differences in the impact forces generated by the two vehicles during the collision.

4.2 OCCUPANT PARAMETERS

A comparison of available occupant stroking distances is presented in Table 4-4, but a lack of data from C-31 presented difficulty in making an assessment of aggressivity for the light truck. Occupant response data from the three tests used in this comparison are summarized in Table 4-5.

TABLE 4-1. COMPARISON OF VEHICLE-TO-SMALL CAR OFFSET COLLISION RESULTS

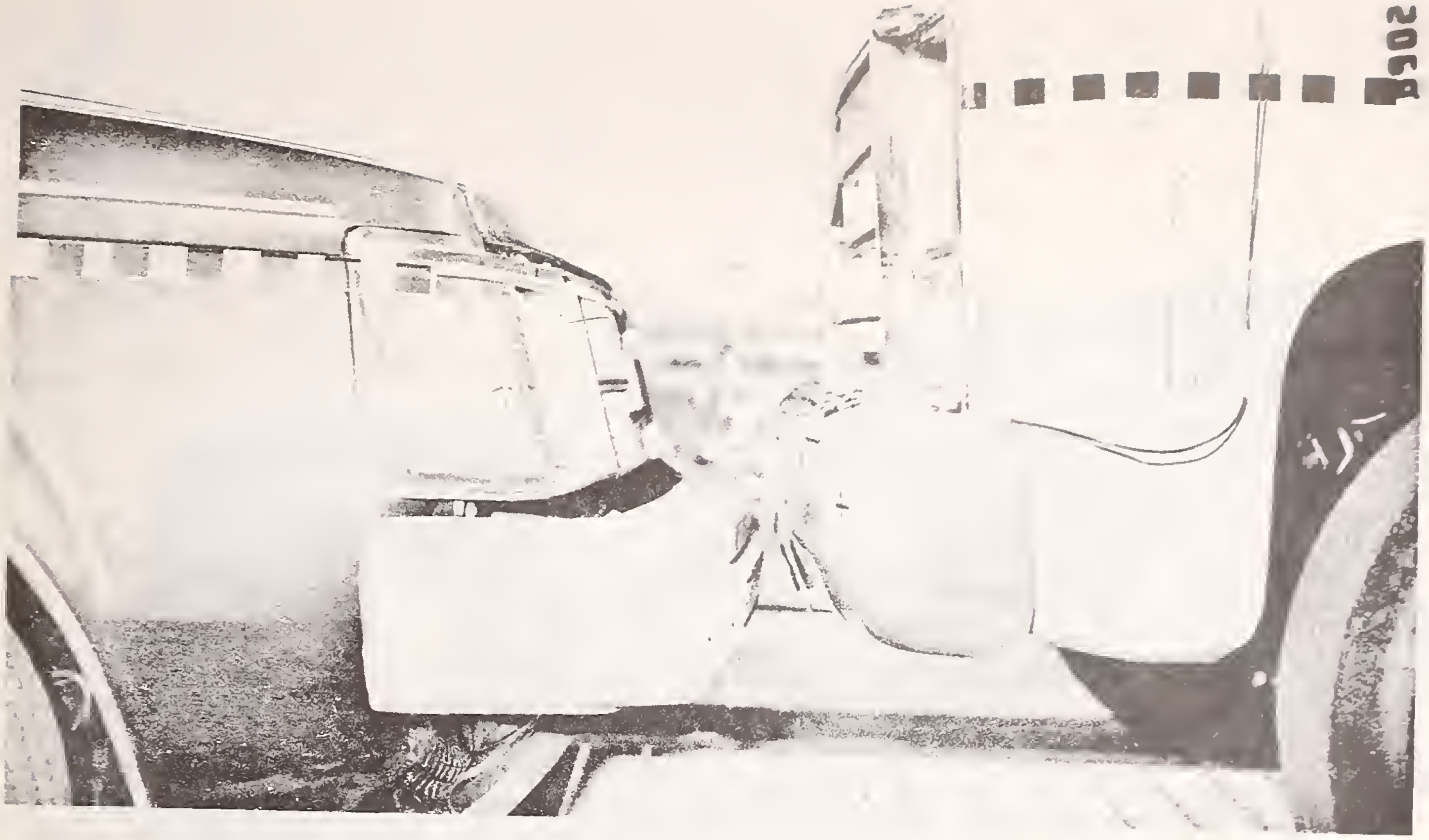
	Test 3051-5		Test C-3	
Vehicle Data	1979 Chevrolet C-10 Truck	1978 Plymouth Horizon	1978 Chevrolet Impala	1976 Volkswagen Rabbit
Overall Length/Width (in.)	217.0/78.0	162.4/66.2	212.5/ND	155.0/ND
Test Weight by Wheel (lb)	LF: 1437 RF: 1331 LR: 1215 RR: 1200	LF: 762 RF: 743 LR: 591 RR: 586	LF: 1100 RF: 1100 LR: 850 RR: 850	LF: 600 RF: 740 LR: 470 RR: 440
Test Weight (lb)	5183	2682	3900	2250
Wheelbase (in.)	131.8	99.5	116	94.5
Longitudinal C.G. (From Center of Front Axle) (in.)	61.4	43.7	50.6	38.2
Impact Angle (deg)*	0	0	0	0
Offset Distance (in.)**	0	-21.0	0	-26
Car Speed (mph)	+30.8	+30.8	+27.7	+27.7
Final Speed (mph @ msec)	+4.9 @ 200	-13.4 @ 200	+7.6 @ 205	-8.6 @ 160
Velocity Change (mph)	25.9	44.2	21.1	36.3
Maximum Average Compartment Acceleration (G @ msec)	-19.4 @ 73	-32.4 @ 56	-15.2 @ 39	-30.0 @ 35
Maximum Engine Acceleration (G @ msec)	-48.6 @ 44	-87.2 @ 40	-23.8 @ 50	-64.5 @ 41
Maximum Mutual Dynamic Crush (Film Data) (in.)	63.3		ND	
Maximum Static Crush				
• Hood Level (in.)	7.4	19.1	ND	ND
• Between Hood/Bumper (in.)	16.0	28.4	ND	ND
• Front Bumper Level (in.)	29.5	22.8	9.8	27.5
Maximum Post-test Intrusion (in.)	3.6	8.4	ND	8.7

*With respect to tow track centerline.
**Right offset between vehicle centerlines.
ND = No Data.

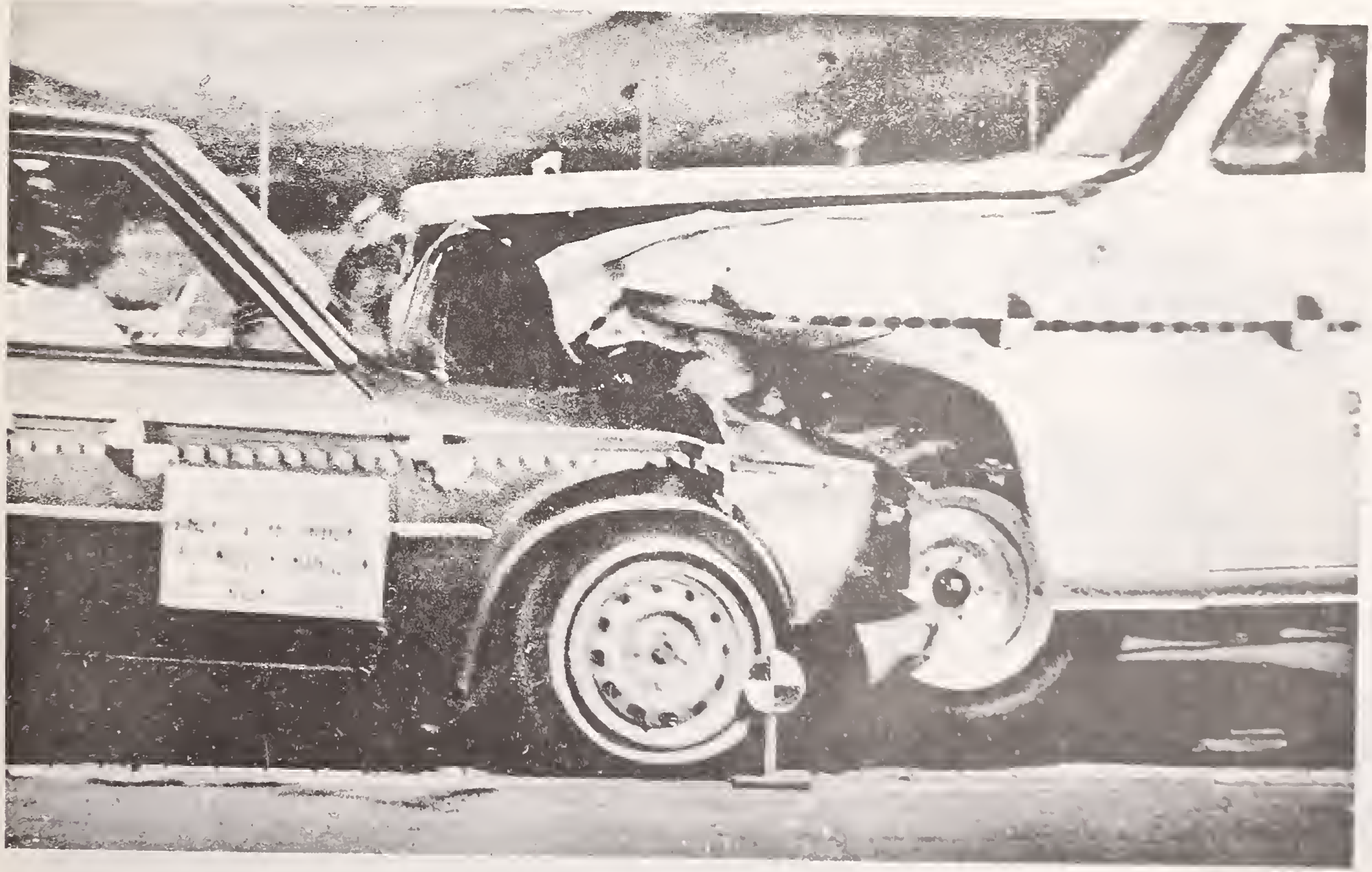
TABLE 4-2. COMPARISON OF VEHICLE-TO-LARGE CAR OFFSET COLLISION RESULTS

	Test 3051-6		Test C-3	
Vehicle Parameters	1979 Chevrolet C-10 Truck	1979 Chevrolet Impala	1978 Chevrolet Impala	1976 Volkswagen Rabbit
Overall Length/Width (in.)	217.2/	211.0/	212.5/ND	155.0/ND
Test Weight by Wheel (lb)	LF: 1407 RF: 1331 LR: 1246 RR: 1192	LF: 1105 RF: 1111 LR: 1100 RR: 1081	LF: 1100 RF: 1100 LR: 850 RR: 850	LF: 600 RF: 740 LR: 470 RR: 440
Test Weight (lb)	5176	4397	3900	2250
Wheelbase (in.)	131.6	116.1	116.0	94.5
Longitudinal C.G. (From Center of Front Axle) (in.)	62.0	58.6	50.6	38.2
Impact Angle (deg)*	0	0	0	0
Offset Distance (in.)**	0	-21.0	0	-26.0
Car Speed (mph)	+37.9	+37.9	+27.7	+27.7
Final Speed (mph @ msec)	+3.0 @ 200	-8.6 @ 200	+7.6 @ 205	-8.6 @ 160
Velocity Change (mph)	34.9	46.49	21.1	36.3
Maximum Average Compartment Acceleration (G @ msec)	-27.7 @ 46	-33.3 @ 54	-15.2 @ 39	-30.0 @ 35
Maximum Engine Acceleration (G @ msec)	-70.1 @ 37	-126.4 @ 41	-23.8 @ 50	-64.5 @ 41
Maximum Mutual Dynamic Crush (Film Data) (in.)	92.3		ND	
Maximum Static Crush				
o Hood Level (in.)	35.7	44.6	ND	ND
o Between Hood/Bumper (in.)	40.4	45.6	ND	ND
o Front Bumper Level (in.)	50.9	48.9	9.8	27.5
Maximum Post-test Intrusion (in.)	11.9	7.8	ND	8.7

*With respect to tow track centerline.
**Right offset between vehicle centerlines.
ND = No Data.

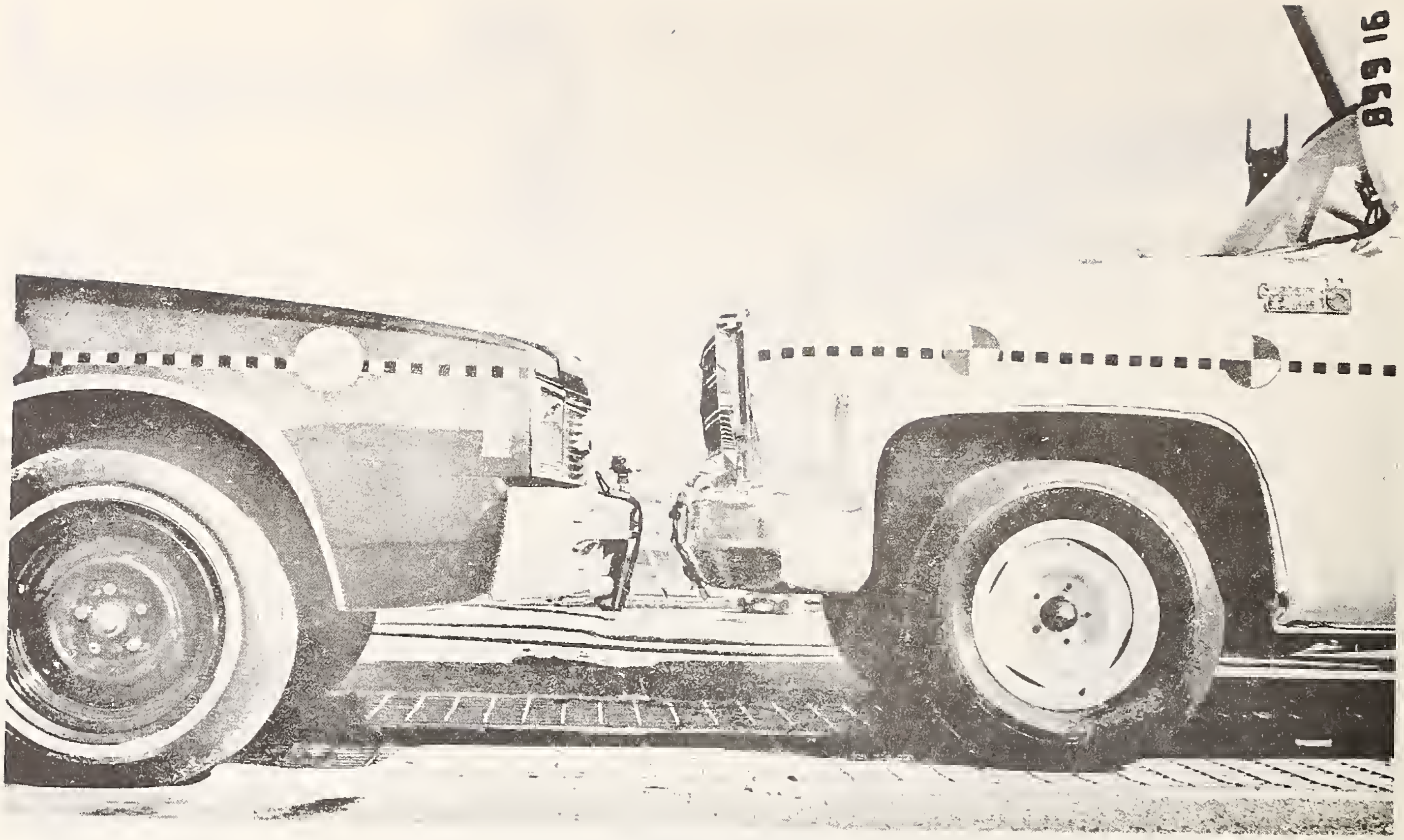


a) Pre-test

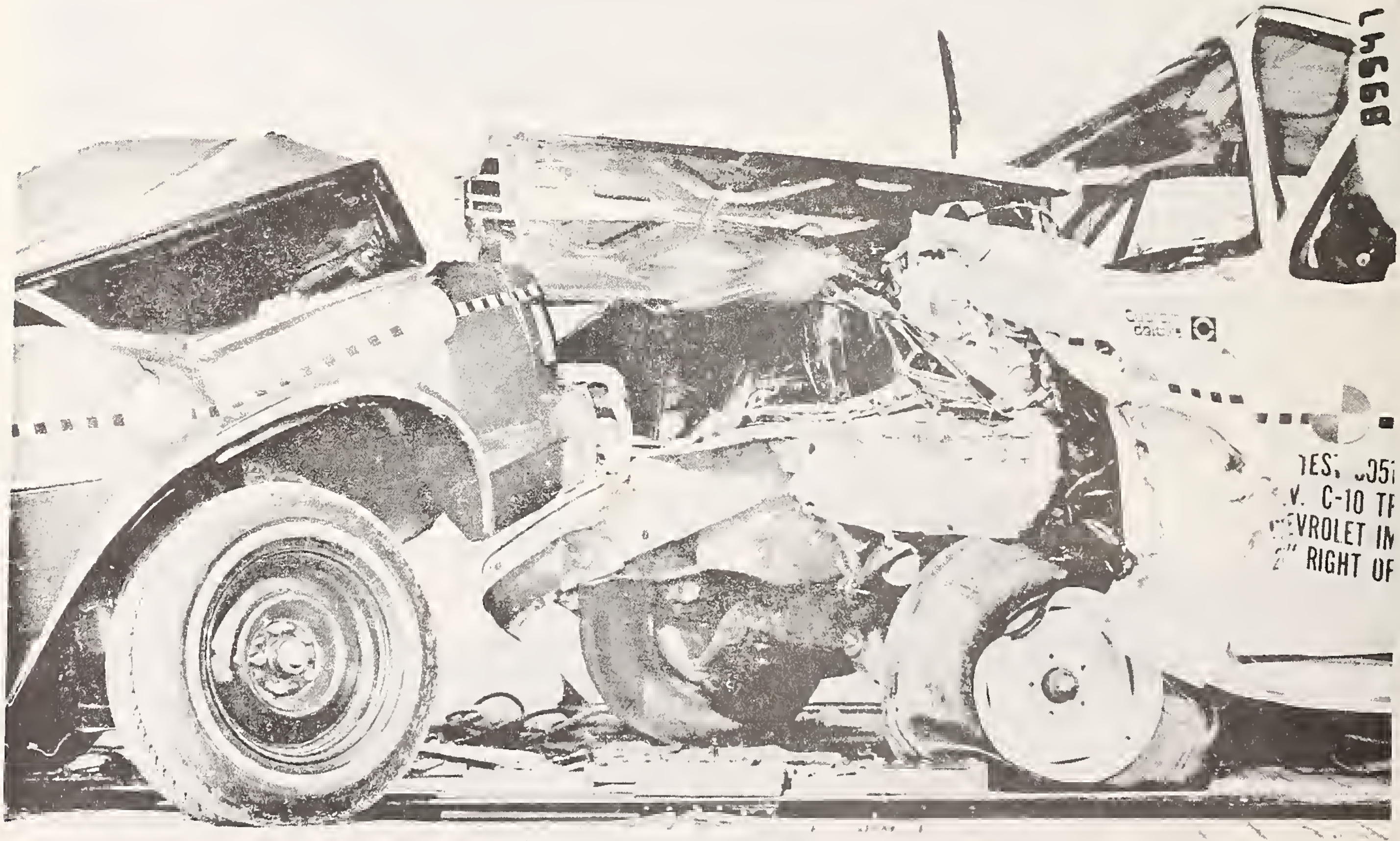


b) Impact

Figure 4-1. Chevrolet C-10 Truck/Plymouth Horizon Bumper Matchup (Test 3051-5).



a) Pre-test



b) Post-test

Figure 4-2. Chevrolet C-10 Truck/Chevrolet Impala Bumper Matchup (Test 3051-6).

TABLE 4-3. BUMPER/ENGINE CHARACTERISTICS

	Test 3051-5		Test 3051-6		Test C-3	
	1979 Chevrolet C-10 Truck	1978 Plymouth Horizon	1979 Chevrolet C-10 Truck	1979 Chevrolet Impala	1978 Chevrolet Impala	1976 Volkswagen Rabbit
Engine Size (CID)	350	105	350	350	ND	ND
Engine Weight (lb)*	675	475	675	675	ND	ND
Engine Height (in.)	35.1	30.0	34.9	30.1	ND	ND
Bumper to Engine (in.)	28.9	17.0	29.2	34.8	ND	ND
Hood Level Height (in.)	39.7	29.7	39.1	31.2	ND	38.0
Maximum Bumper Height (in.)	24.4	21.1	24.0	22.8	ND	ND
Minimum Bumper Height (in.)	15.0	15.9	14.9	13.0	ND	ND
Maximum Post-test Static Crush (in.)	29.5	22.8	50.9	48.9	ND	8.7
Bumper Override/ Underride	Override	Underride	Pushed Back	Pushed Back	Override	Underride

*Total dressed engine plus transmission.
ND = No Data Available.

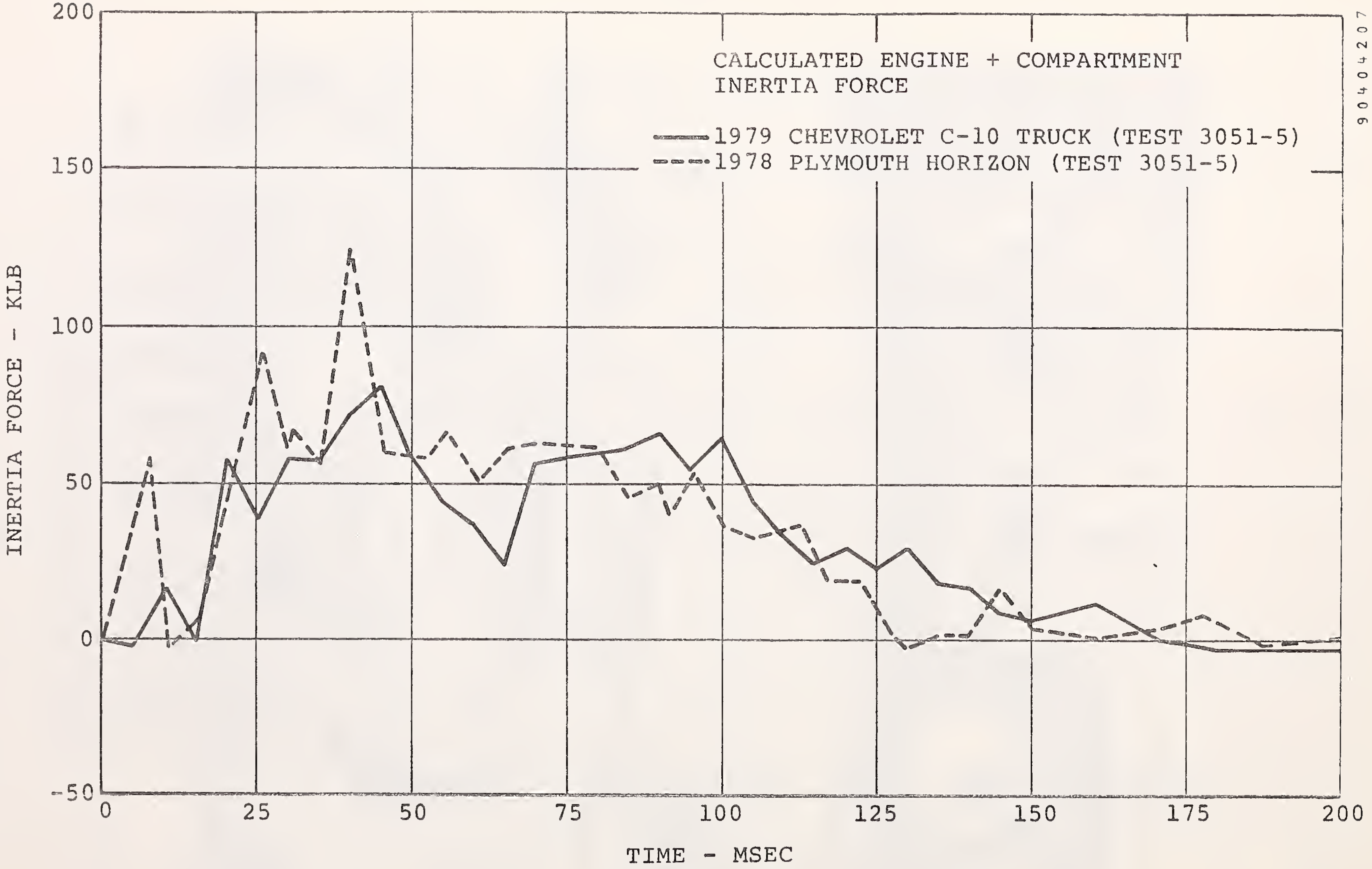


Figure 4-3. Chevrolet C-10 Truck/Plymouth Horizon Inertia Force Comparison.

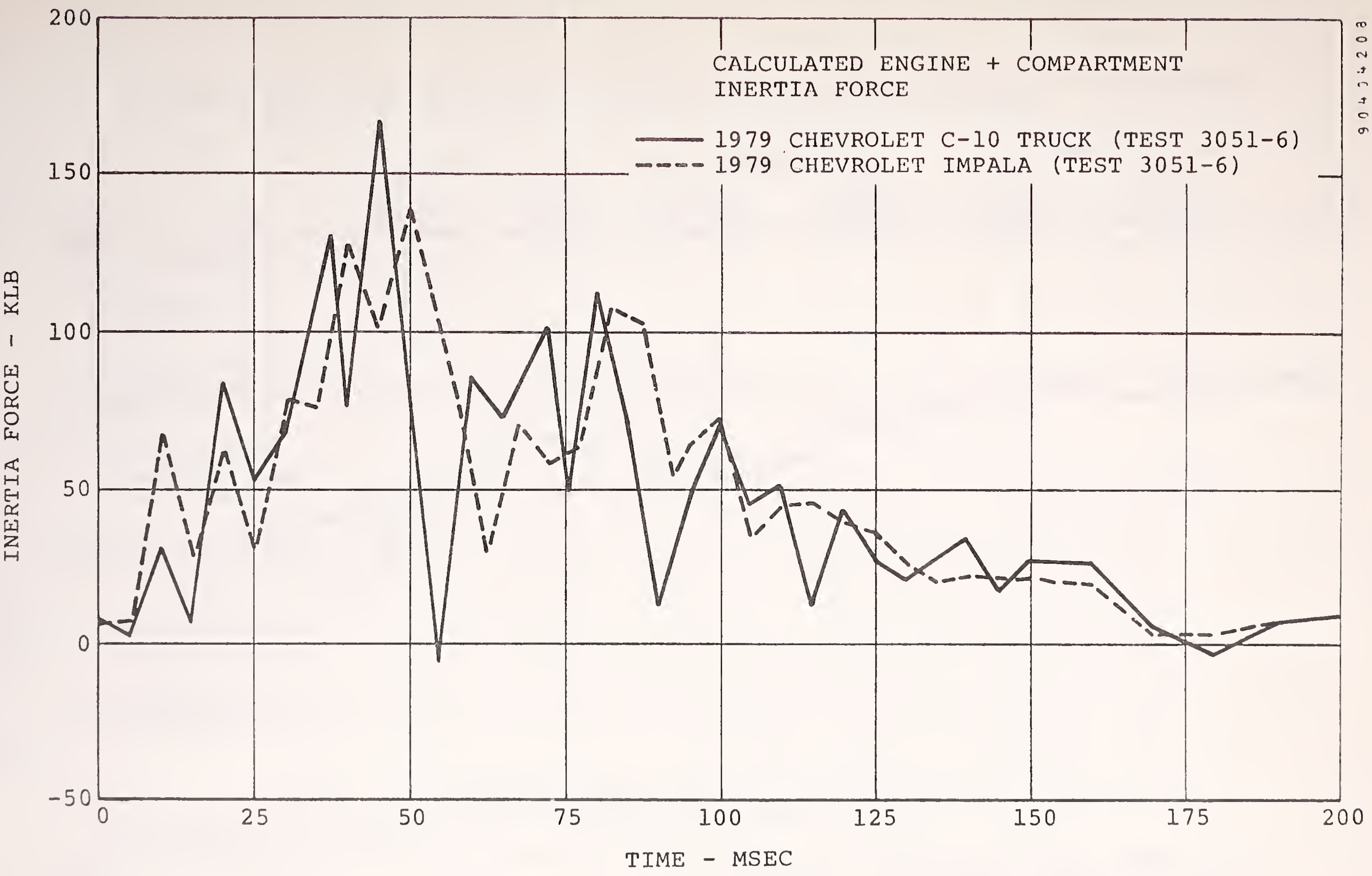


Figure 4-4. Chevrolet C-10 Truck/Chevrolet Impala Inertia Force Comparison.

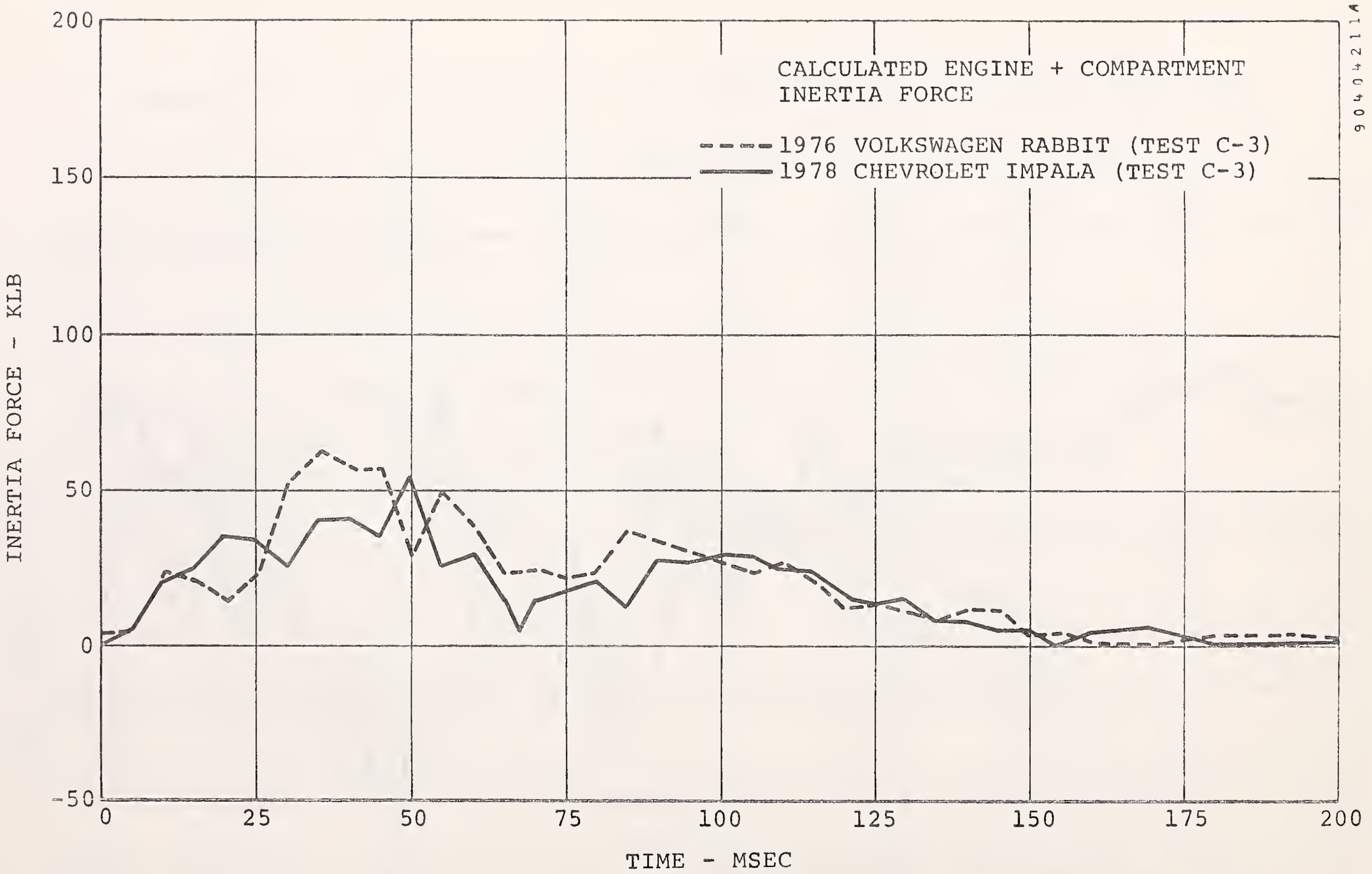


Figure 4-5. Chevrolet Impala/Volkswagen Rabbit Inertia Force Comparison.

TABLE 4-4. TEST VEHICLE OCCUPANT AVAILABLE STROKING DISTANCES

	Test 3051-5				Test 3051-6				Test C-3			
	1979 Chevrolet C-10 Truck		1978 Plymouth Horizon		1979 Chevrolet C-10 Truck		1979 Chevrolet Impala		1978 Chevrolet Impala		1976 Volkswagen Rabbit*	
Parameter	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF	LF	RF
Forehead to Header (in.)	18.6	22.0	13.0	14.0	18.5	20.3	13.6	14.4	ND	ND	16.8	17.5
Head to Windshield (Horizontal) (in.)	25.0	28.0	19.8	21.4	25.0	25.9	21.9	21.6	ND	ND	21.8	20.4
Chest to Dash Panel (Horizontal) (in.)	24.6	25.4	20.4	24.3	25.5	23.4	20.8	19.9	ND	ND	19.5	19.5
Nose-to-Upper Steering Wheel Rim (in.)	14.6	-	17.4	-	15.0	-	14.8	-	ND	ND	18.2	-
Chest to Steering Wheel Hub (in.)	11.6	-	16.1	-	11.3	-	12.8	-	ND	ND	10.7	-
Knee to Lower Dash Panel (in.)												
Left	8.0	6.1	7.3	7.3	8.7	6.3	7.6	8.5	ND	ND	2.3	2.3
Right	8.6	6.0	7.3	7.1	8.3	6.8	8.4	8.4	ND	ND	2.3	2.3

*Vehicle contained production passive seat belt restraint system.
ND = No Data Available.

TABLE 4-5. SUMMARY OF OCCUPANT RESPONSE DATA - OFFSET CRASH TESTS

	Test 3051-5				Test 3051-6				Test C-3				
	1979 Chevrolet C-10 Truck		1978 Plymouth Horizon		1979 Chevrolet C-10 Truck		1979 Chevrolet Impala		1978 Chevrolet Impala		1976 Volkswagen Rabbit**		
Occupant Response	LF	RF(1)	LF	RF	LF	RF(1)	LF	RF	LF	RF	LF	RF	FMVSS 208 Criteria
HIC	470	ND	1070	1021	1173	ND	2408	1489	100	92.4	278	297	<1000
Head Resultant (G)*	61.7	ND	67.5	68.8	110.5	ND	131.0	106.0	24.0	19.5	38	31	None
CSI	215	ND	520	453	663	ND	848	548	54	48	220	160	<1000
Chest Resultant (G)*	38.6	ND	56.2	450	86.0	ND	81.5	57.8	18.5	16.8	34	28	<60 G
Femur Load (lb)													
Left	ND	ND	-1669	-1047	ND	ND	-1016	-678	+425	+425	+1830	+1900	<2250 lb
Right	ND	ND	-1244	-754	ND	ND	-2143	-754	+350	+200	+1200	+780	<2250 lb

(1) Dummy uninstrumented.

*3 msec clip.

**Vehicle contained production passive seat belt restraint system.

4.3 COMPARATIVE EVALUATION

Based on the vehicle parameters, the aggressivity of the Chevrolet C-10 truck appears to be slightly more than that for the Chevrolet Impala. The velocity change and the occupant compartment acceleration are noticeably higher for the Plymouth Horizon than they are for the VW Rabbit. The crush parameters, static crush, and post-test intrusion are slightly less for the Horizon. Examination of the target vehicle occupant response data indicates the C-10 truck is noticeably more aggressive. The responses for the occupants of the Plymouth Horizon are noticeably higher than those for the VW Rabbit. HIC for the front seat occupants of the Plymouth Horizon is higher by a factor of 3. In addition, chest G are noticeably higher although still within the FMVSS 208 criteria.

4.4 CONCLUSION

Since the target vehicles in the comparisons were not identical, it is difficult to provide a complete assessment of the relative aggressivity of the truck with respect to a typical passenger car. However, the C-10 truck appears to be more aggressive than the Chevrolet Impala in frontal offset collisions. It can be observed that the target driver head and chest response in the truck offset tests were much higher than for the Chevrolet-Volkswagen offset test. The frontal areas of the Impala and truck are similar, but the truck bumper is higher from the ground and could influence steering wheel motions and driver response. However, results may be due to the higher speeds in the 3051 test series, and not to the increased aggressivity of the truck.

In order to assess this more reliably, it is recommended that a Chevrolet Impala-to-Plymouth Horizon frontal offset test be conducted to provide an exact comparison (at the same speed) for this crash environment.

5.0 LIGHT TRUCK AGGRESSIVITY IN REAR-END IMPACTS

5.1 STRUCTURAL PARAMETERS

For the rear-end collision mode, actual tests were run with comparable target vehicles that provided a good data base for assessing light truck aggressivity. These tests were 3051-7 and 3051-8. The target vehicle in Test 3051-7 was a 1978 Plymouth Horizon; the target vehicle in Test 3051-8 was its Dodge sister, the Omni.

It should be noted that in Test 3051-7, the truck was repaired from Test 3051-3. The Chevrolet Caprice used in Test 3051-8 was used in a FMVSS 301 fuel leakage rear-end crash test and modified to a crashable condition. The Dodge Omni was repaired after a FMVSS 210 seat belt anchorage test.

Comparison of the structural response data for these two tests is shown in Table 5-1. These data provide a consistent basis for assessing the aggressivity for the light truck.

For determining architectural aggressivity, the front and rear vehicle geometries for the test vehicle are shown in Figures 5-1 and 5-2. Dimensional data for each vehicle is given in Table 5-2. Bumper matchups are shown in Figures 5-3 and 5-4.

A comparison of the inertia forces in the Chevrolet Caprice and Chevrolet C-10 truck is presented in Figure 5-5, while the same comparison for the Plymouth Horizon and Dodge Omni is shown in Figure 5-6.

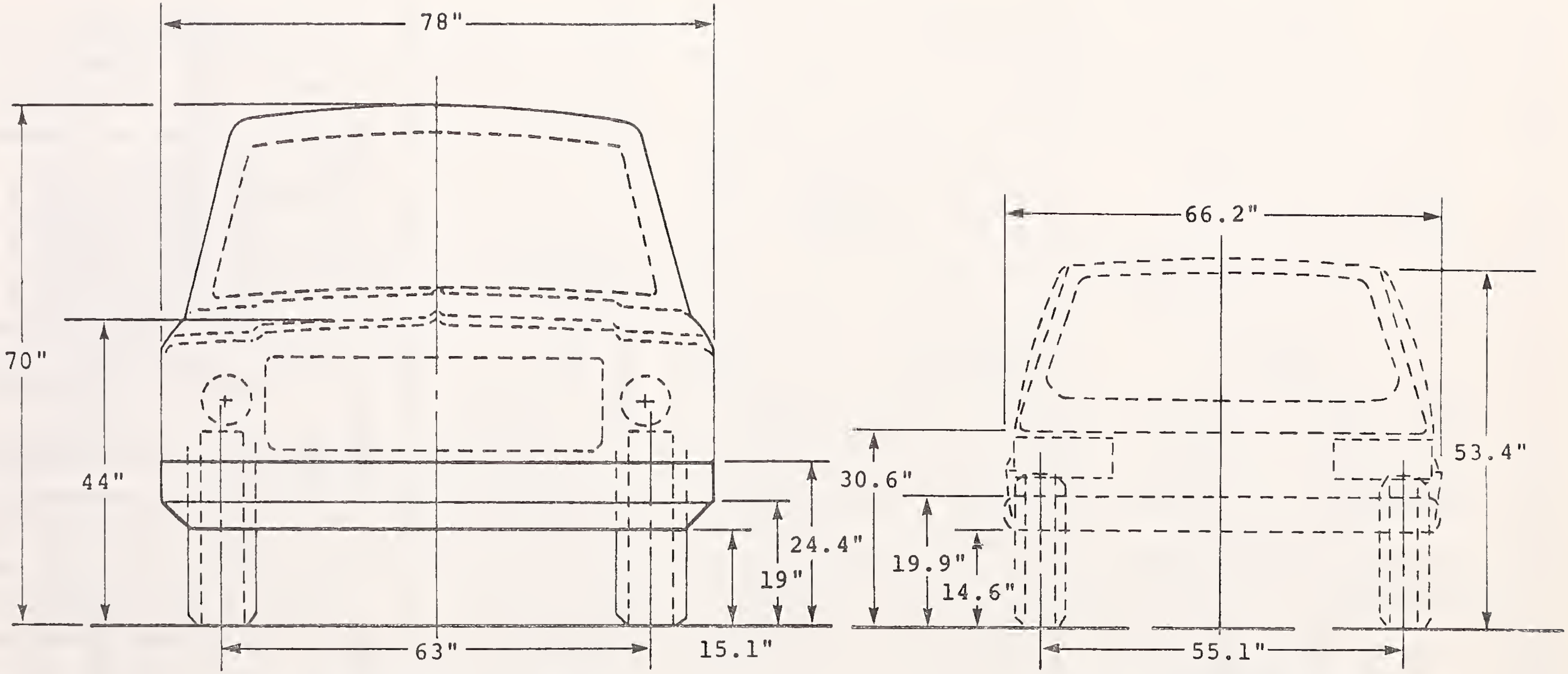
5.2 OCCUPANT PARAMETERS

A comparison of available stroking distances for occupants in the four vehicles involved in these two tests is shown in Table 5-3.

TABLE 5-1. COMPARISON OF VEHICLE-TO-VEHICLE REAR-END COLLISION RESULTS

	Test 3051-7		Test 3051-8	
Vehicle Data	1979 Chevrolet C-10 Truck	1978 Plymouth Horizon	1978 Chevrolet Caprice	1978 Dodge Omni
Overall Length/Width (in.)	217.0/78.0	162.4/66.2	196.9/ND	162.0/66.2
Test Weight by Wheel (lb)	LF: 1406 RF: 1320 LR: 1227 RR: 1225	LF: 882 RF: 959 LR: 555 RR: 612	LF: 1070 RF: 1066 LR: 1110 RR: 1136	LF: 943 RF: 985 LR: 617 RR: 617
Test Weight (lb)	5178	3008	4382	3162
Wheelbase (in.)	131.8	99.3	112.7	99.5
Longitudinal C.G. (From Center of Front Axle) (in.)	62.4	38.5	57.8	38.8
Impact Angle (deg)*	0	0	0	0
Offset Distance (in.)	0	0	0	0
Car Speed (mph)	40.3	0	39.9	0
Final Speed (mph @ msec)	+23.1 @ 188	+29.7 @ 161	+21.4 @ 137	+24.2 @ 137
Velocity Change (mph)	-17.2	+29.7	-18.4	+24.2
Maximum Average Compartment Acceleration (G @ msec)	-15.9 @ 33	+19.4 @ 65	-11.7 @ 32	+20.9 @ 102
Maximum Engine Acceleration (G @ msec)	-12.6 @ 71	+72.6 @ 63	-19.5 @ 86	+57.6 @ 12
Maximum Mutual Dynamic Crush (Film Data) (in.)	47.2		50.0	
Maximum Static Crush				
• Hood Level (in.)	11.2		5.9	
• Between Hood/Bumper (in.)	13.6		10.4	
• Front Bumper Level (in.)	6.3		1.5	
• Trunk Level (in.)		13.6		23.7
• Between Trunk/Bumper (in.)		22.3		24.9
• Rear Bumper Level (in.)		15.7		15.7
Maximum Post-test Intrusion (in.)	0.4	NA	0.9	NA

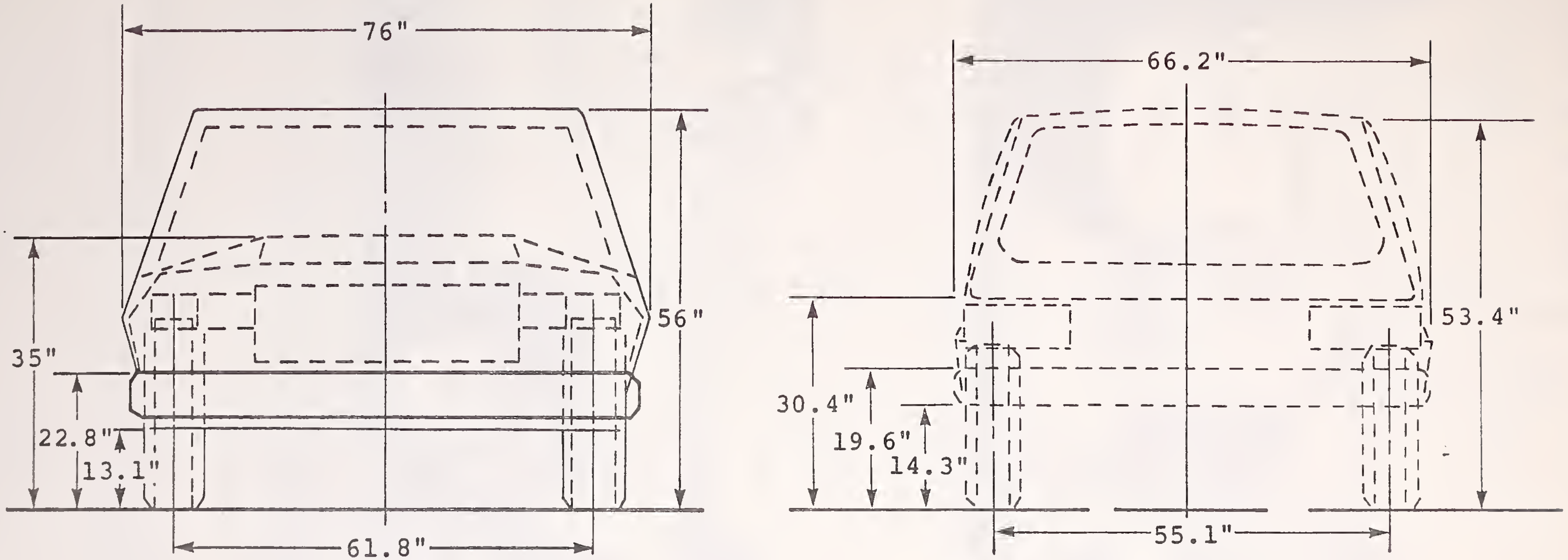
*With respect to tow track centerline.
NA = Not Applicable.



1979 CHEVROLET C-10 TRUCK

1978 PLYMOUTH HORIZON

Figure 5-1. Chevrolet C-10 Truck Front/Plymouth Horizon Rear Vehicle Geometry (Test 3051-7).



1978 CHEVROLET CAPRICE

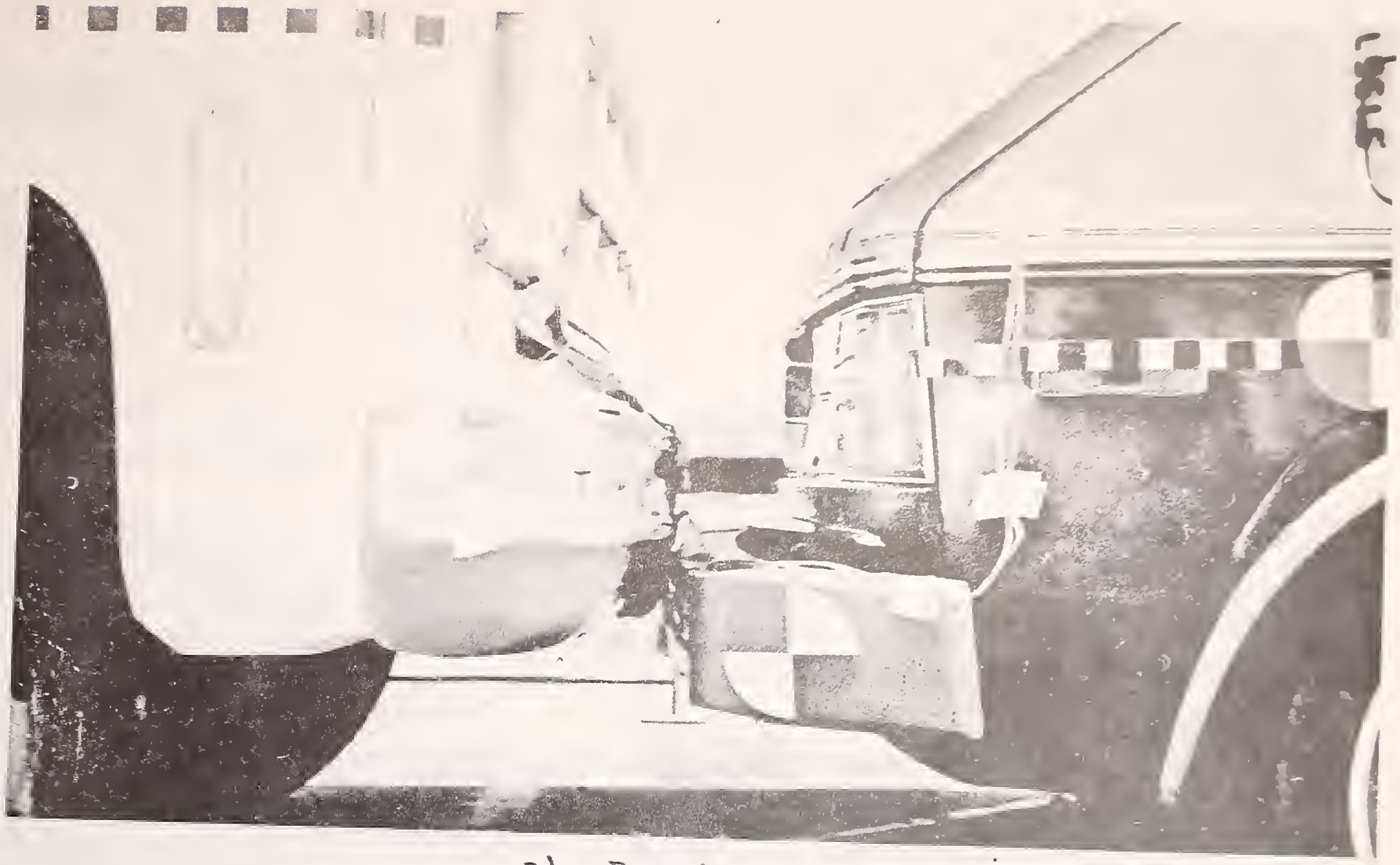
1978 DODGE OMNI

Figure 5-2. Chevrolet Caprice Front/Dodge Omni Rear Vehicle Geometry (Test 3051-8).

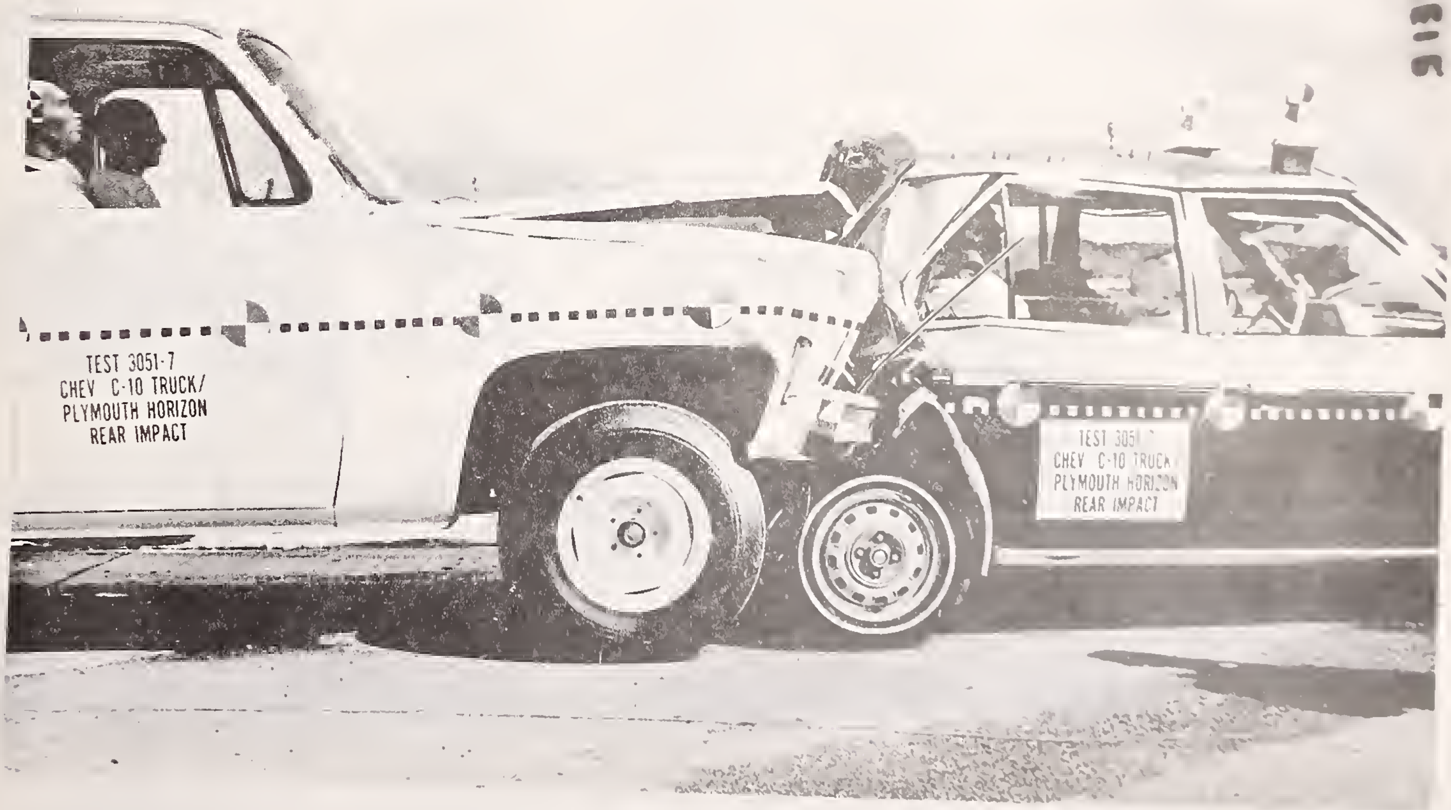
TABLE 5-2. BUMPER/ENGINE CHARACTERISTICS

	Test 3051-7		Test 3051-8	
	1979 Chevrolet C-10 Truck	1978 Plymouth Horizon	1978 Chevrolet Caprice	1978 Dodge Omni
Engine Size (CID)	350	105	305	105
Engine Weight (lb)*	675	475	688	475
Engine Height (in.)	35.0	30.0	30.7	29.3
Bumper to Engine (in.)	28.3	17.1	34.7	16.5
Hood Level Height (in.)**	39.2	30.6	31.4	30.4
Maximum Bumper Height (in.)***	24.4	19.9	22.8	19.6
Minimum Bumper Height (in.)***	15.1	14.6	13.1	14.3
Maximum Post-test Static Crush (in.)	13.6	22.3	10.4	24.9
Bumper Override/ Underride	Override	Underride	Override	Underride

*Total dressed engine plus transmission.
**Bottom of hatchback to ground for Horizon and Omni.
***Front bumper for C-10 Truck and Caprice. Rear bumper for Horizon and Omni.

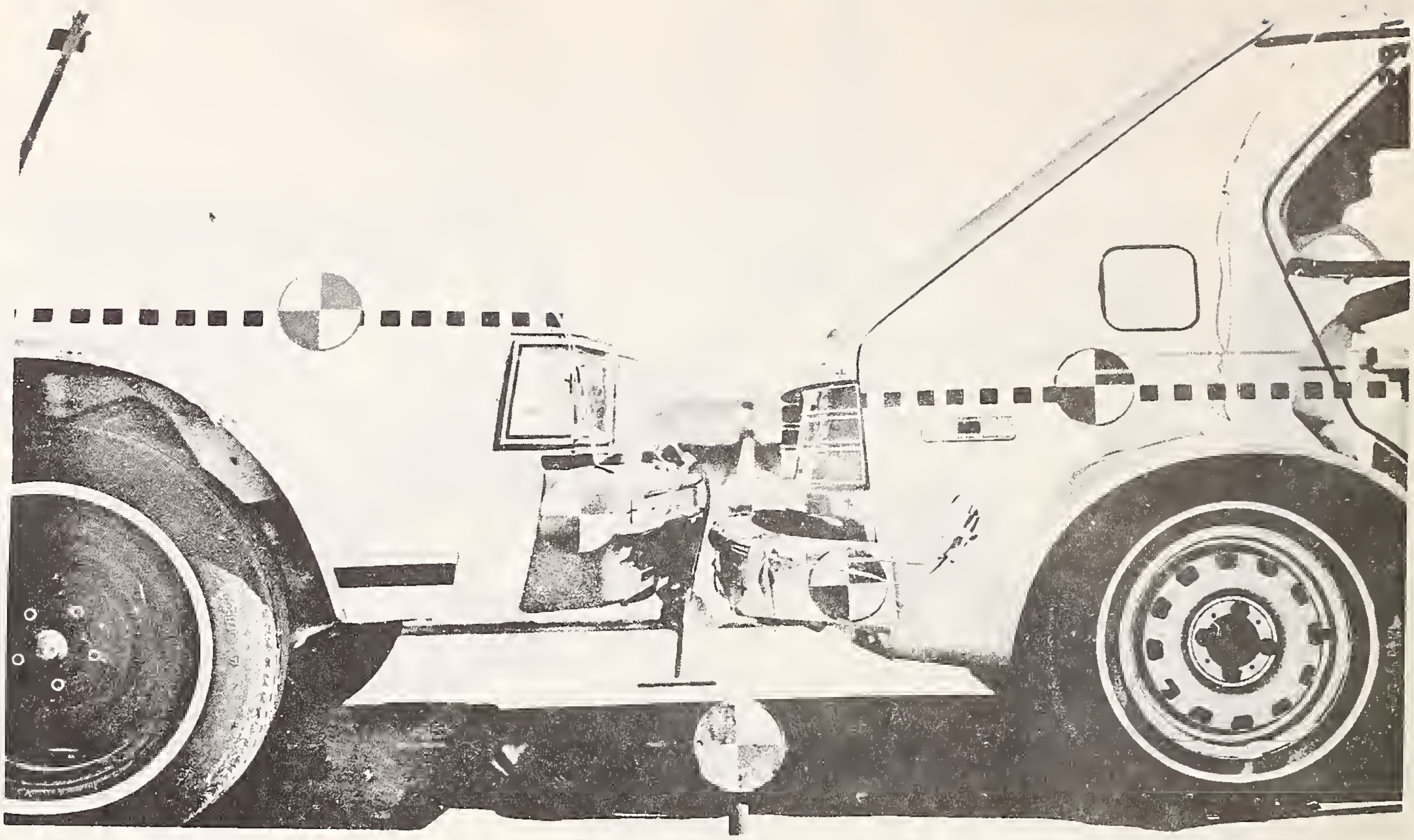


a) Pre-test



b) Post-test

Figure 5-3. Chevrolet C-10 Truck Front/Plymouth Horizon Rear Bumper Matchup (Test 3051-7).



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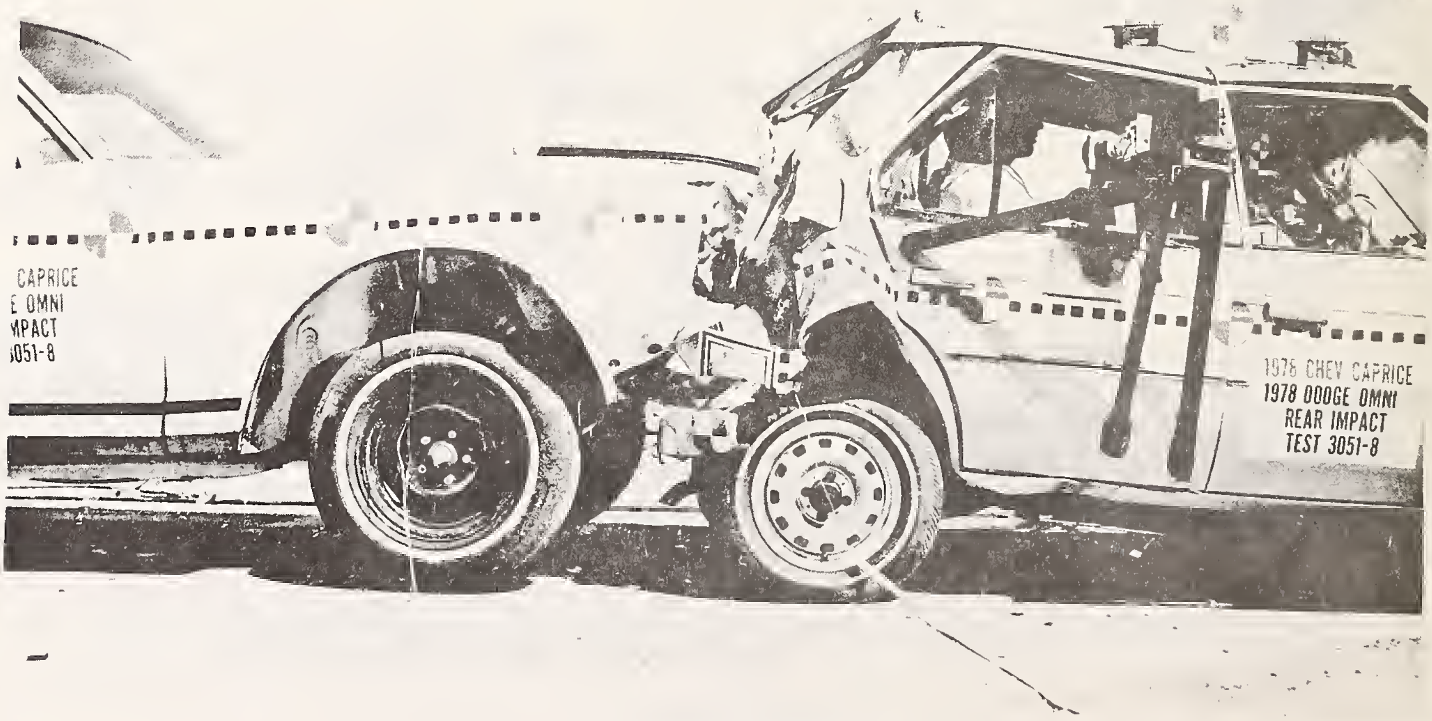

b) Post-test

Figure 5-4. Chevrolet Caprice Front/Dodge Omni Rear Bumper Matchup (Test 3051-8).

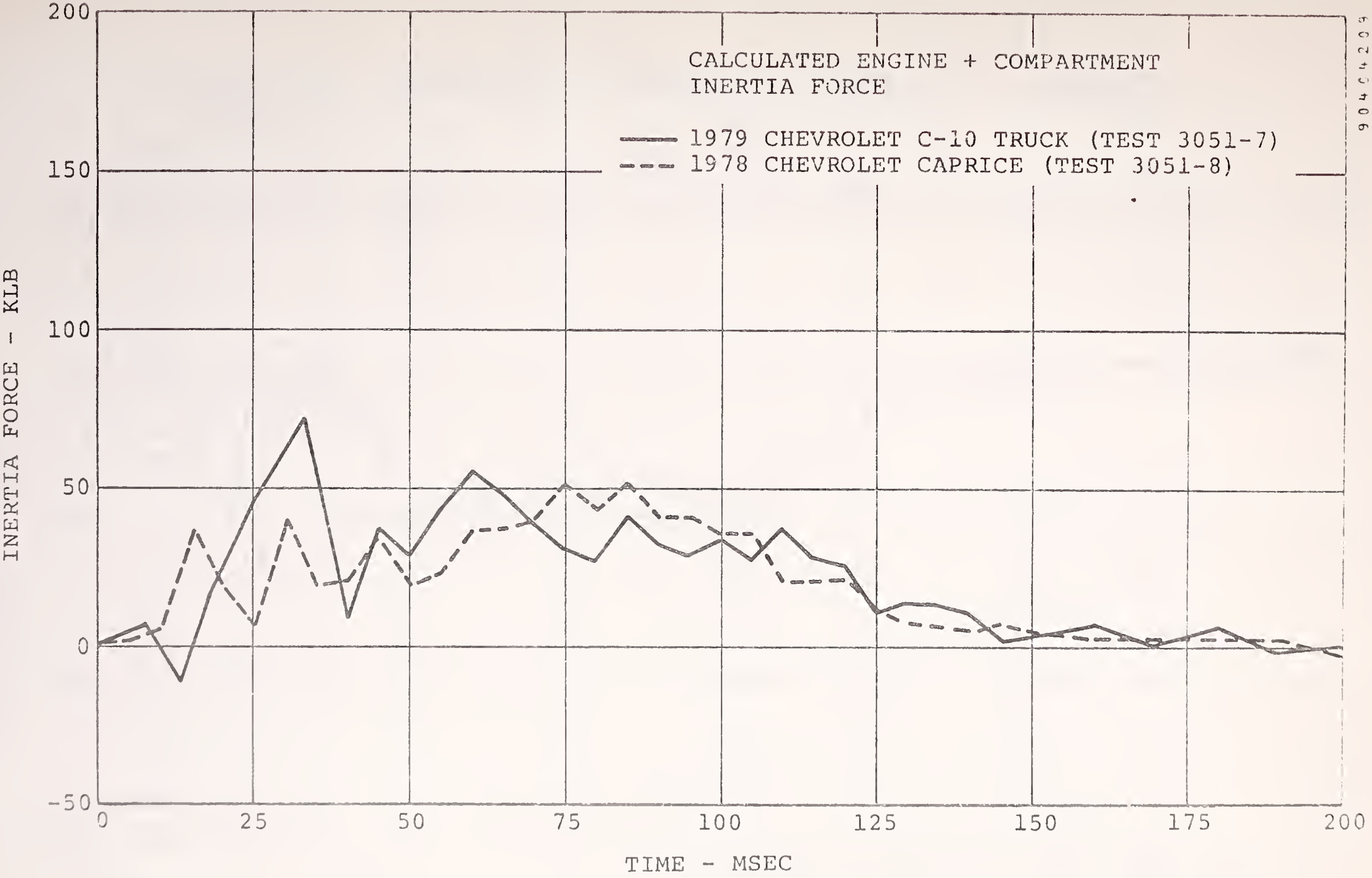

Figure 5-5. Chevrolet C-10 Truck/Chevrolet Caprice Inertia Force Comparison.

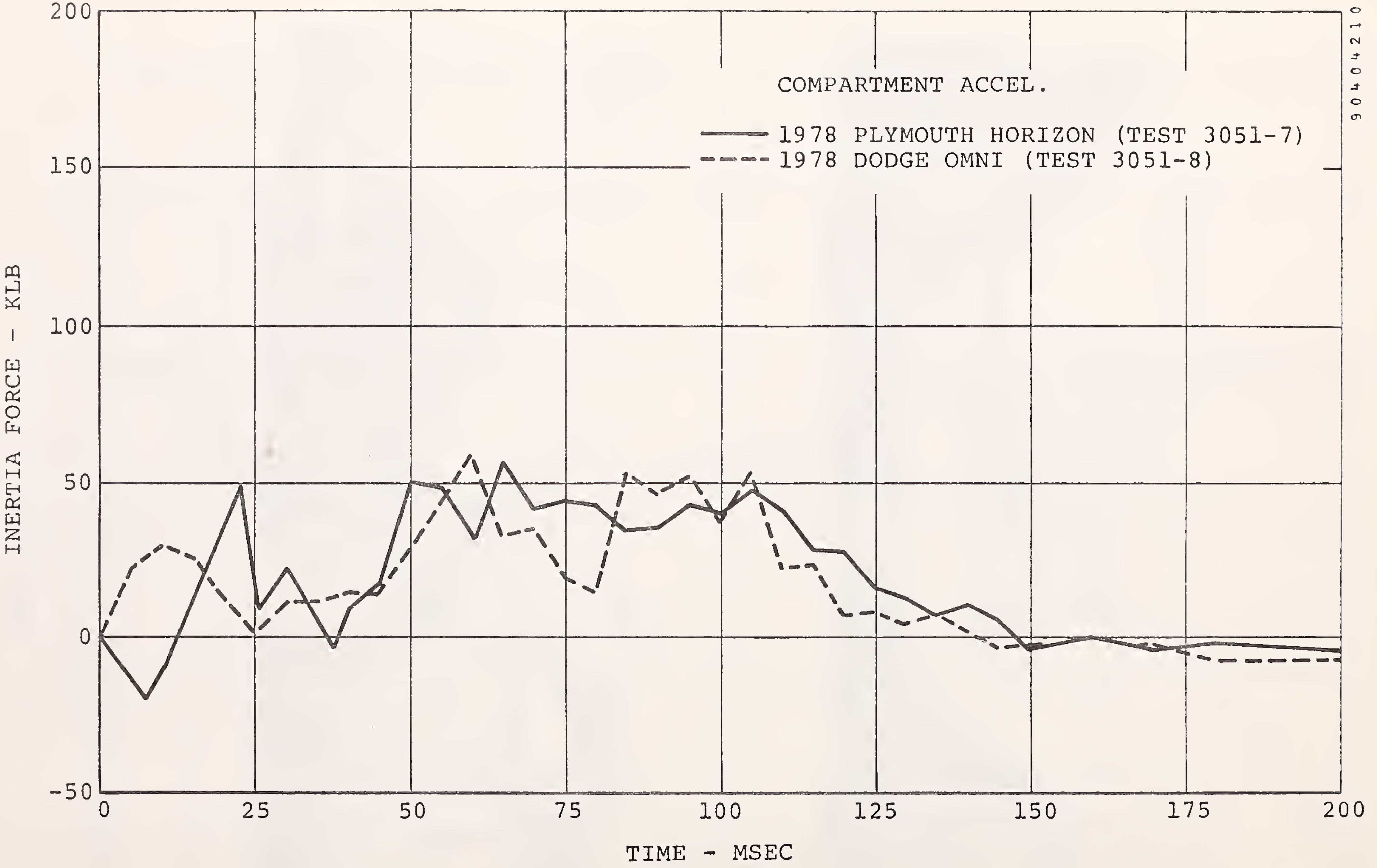

Figure 5-6. Plymouth Horizon/Dodge Omni Inertia Force Comparison.

TABLE 5-3. TEST VEHICLE OCCUPANT COMPARTMENT AVAILABLE STROKING DISTANCES

	Test 3051-7				Test 3051-8			
	1979 Chevrolet C-10 Truck		1978 Plymouth Horizon		1978 Chevrolet Caprice		1978 Dodge Omni	
Front Seat Dummy Dimension	LF	RF	LF	RF*	LF	RF	LF	RF
Forehead to Header (in.)	18.8	19.9	14.0	-	17.3	16.8	12.4	12.1
Head to Windshield (Horizontal) (in.)	25.0	25.2	21.0	-	24.6	24.4	18.8	19.0
Chest to Dash Panel (Horizontal) (in.)	25.1	23.1	21.0	-	21.8	22.0	20.0	22.6
Nose to Upper Steering Wheel Rim (in.)	15.2	-	18.2	-	17.0	-	16.6	-
Chest to Steering Wheel Hub (in.)	11.4	-	16.6	-	13.2	-	14.6	-
Knee to Lower Panel (in.)								
Left	7.9	6.6	7.2	-	7.0	7.7	6.5	7.2
Right	7.8	6.9	8.3	-	6.9	7.6	6.7	7.0
Rear Seat Dummy Dimension			LR*	RR			LR	RR
Head to Rear Header (in.)			-	1.8			1.7	1.9
Head to Rear Windshield (in.)			-	8.7			8.4	8.7
Chest to Front Seat Back (in.)			-	19.4			21.0	20.8
Nose to Front Seat Back (in.)			-	21.0			22.3	22.4
Knee to Front Seat Back (in.)								
Left			-	3.9			4.3	4.1
Right			-	4.0			4.5	4.0

*No dummy in this seating position.

The occupant response data for these two tests is summarized in Table 5-4.

It should be noted that the Horizon test contained two dummies (RF and LR) while the Omni test contained four dummies. The additional dummies in the Omni test had a strong influence on the dynamics of the RF and LR occupants. Thus, although the target vehicles were similar, the occupant characteristics were not. This difference compromises the use of dummy data for truck aggressivity assessment.

5.3 COMPARATIVE EVALUATION

Comparing the vehicle parameters from Tests 3051-7 and 3051-8 (see Table 5-1), there does not appear to be much difference between the Chevrolet C-10 truck and the Chevrolet Caprice. The compartment accelerations and the crush distances are of approximately the same magnitude. The velocity change for the Plymouth Horizon though is quite a bit more than that for the Dodge Omni. This is to be expected, based on momentum considerations, since the truck weighs much more than the Chevrolet car. However, some of the extra velocity is due to the higher speed for the Horizon test and the lower weight of the Horizon (with only 2 dummies).

Comparing the occupant response data in Table 5-4 for the Horizon and Omni in these two tests, there does not appear to be any significant difference attributable to the aggressivity of the C-10 truck versus the Caprice. The high femur loads for the Omni rear dummies are attributable to the front dummy forcing his seat backward. Because the impacts were low-speed rear collisions, the values for the occupant response parameters are quite low and preclude any real comparison of the occupant response parameters. The assessment here is that there is no significant difference between the aggressivity of the Chevrolet C-10 truck versus the Caprice since bumper override occured in both tests. There was no fuel system leakage in either test and no dummy ejection.

TABLE 5-4. SUMMARY OF OCCUPANT RESPONSE DATA - SYMMETRIC REAR-END CRASH TESTS

	Test 3051-7				Test 3051-8						
	1979 Chevrolet C-10 Truck		1978 Plymouth Horizon		1978 Chevrolet Caprice		1978 Dodge Omni				
Occupant Response	LF	RF	LF	RR	LF	RF	LF	RF	LR	RR	FMVSS 208 Criteria
HIC	53	ND	109	177	ND	ND	289	248	249	126	<1000
Head Resultant (G)*	16.4	ND	48.5	36.1	ND	ND	54.7	44.6	47.1	29.4	None
CSI	31	ND	95	179	ND	ND	133	161	109	126	<1000
Chest Resultant (G)*	15.2	ND	27.1	35.4	ND	ND	41.4	41.3	27.8	29.3	<60 G
Femur Load (lb)											
Left	ND	ND	-209	-1098	ND	ND	-246	-426	-2328	-1782	<2250 lb
Right	ND	ND	+175	-921	ND	ND	-296	-350	-1993	-2750	<2250 lb

*3 msec clip.
ND = No Data Available.

There was a noteworthy difference in the configuration of the occupants for the Horizon and Omni in the two tests summarized in Table 5-4. In Test 3051-7 the Horizon had two anthropomorphic dummies; one was positioned at the driver position (left front) and the other was positioned at the right rear passenger position. In Test 3051-8, however, the Dodge Omni had four anthropomorphic dummies; two were in the front seats and two in the back seats. During the impact in Test 3051-8, the rear occupants received high femur loads due to the front occupant seats moving into the rear of the occupant compartment. In Test 3051-7, the right rear occupant did see higher femur loads than the left front occupant. This difference between femur loads in the rear occupants is primarily attributed to the fact that in Test 3051-8 there were front seat occupants in front of each rear occupant in the Omni. Had there been two front seat occupants in Test 3051-7, it could be expected that femur loads for the rear passenger would be higher and therefore comparable with those in Test 3051-8. Therefore, this difference did not appear to be due to any particularly aggressive feature of the Chevrolet Caprice and was not included in the assessment of aggressivity for the C-10 truck.

5.4 CONCLUSIONS

After a review of the structural and occupant parameters for rear-end impacts, the overall aggressiveness of the light truck did not show any significant difference in data compared to the full-size passenger car. Since both vehicles overrode the bumpers of the Horizon and Omni, the amount of vehicle crush was about the same. The bumper mismatch in both tests was the major factor contributing to the bullet vehicle's aggressivity. However, at the closing speed under investigation, the potential injury levels were low except for possible femur injury to rear occupants.

This test comparison dramatically illustrated that slight changes to the vehicle configuration (in this case, number of occupants) can result in radical changes in some response parameters (in this case, femur loads).

6.0 CONCLUSIONS AND RECOMMENDATIONS

The previous sections have presented a preliminary assessment of light truck aggressivity relative to a full size passenger car for a number of collision modes. A summary of the assessments is presented in Table 6-1. Looking at the global situation, that is the mix of vehicle collisions presented in Table 6-1 it appears that the c-10 truck is slightly more aggressive than the full size passenger car.

As presented in the previous sections, the vehicle parameter data and occupant response data were qualitatively compared for the various crash modes from this comparison a determination of the aggressivity of each vehicle was made. This assessment however must be considered preliminary at this time, since the data base for comparing the C-10 truck with the full size passenger car was incomplete. Another factor which hinders in assessment of light truck aggressivity is the lack of a definitive methodology for weighting the significant parameters to determine vehicle aggresivity.

Based on the results of this initial analysis, Dynamic Science recommends that the following tasks be accomplished in order to better define the aggressivity of a light truck in comparison to a passenger vehicle.

- Review the data presented in this report in-depth to evaluate the significant parameters for defining vehicle aggressivity.
- Having established this set of vehicle parameters, develop methodologies for quantifying a vehicle's aggressivity.
- Further investigate accident data for light truck/passenger car impacts to determine the accident modes and causes of injury and fatalities being higher for those in the target vehicle.
- Conduct additional car-to-car impact tests under identical conditions as those in Table 1-1 to provide a complete data base for quantitatively assessing light truck aggressivity.

TABLE 6-1. LIGHT TRUCK AGGRESSIVITY ASSESSMENT

	Aggressivity Comparison	
Impact Configuration	Chevrolet C-10 Truck	Chevrolet Passenger Car
Head-on Collision	C-10 Truck slightly less aggressive than passenger car	
Perpendicular Side Impact	C-10 Truck more aggressive than passenger car	
Frontal Offset Collision	C-10 Truck more aggressive than passenger car	
Rear-End Impact	C-10 Truck equally aggressive as passenger car	

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